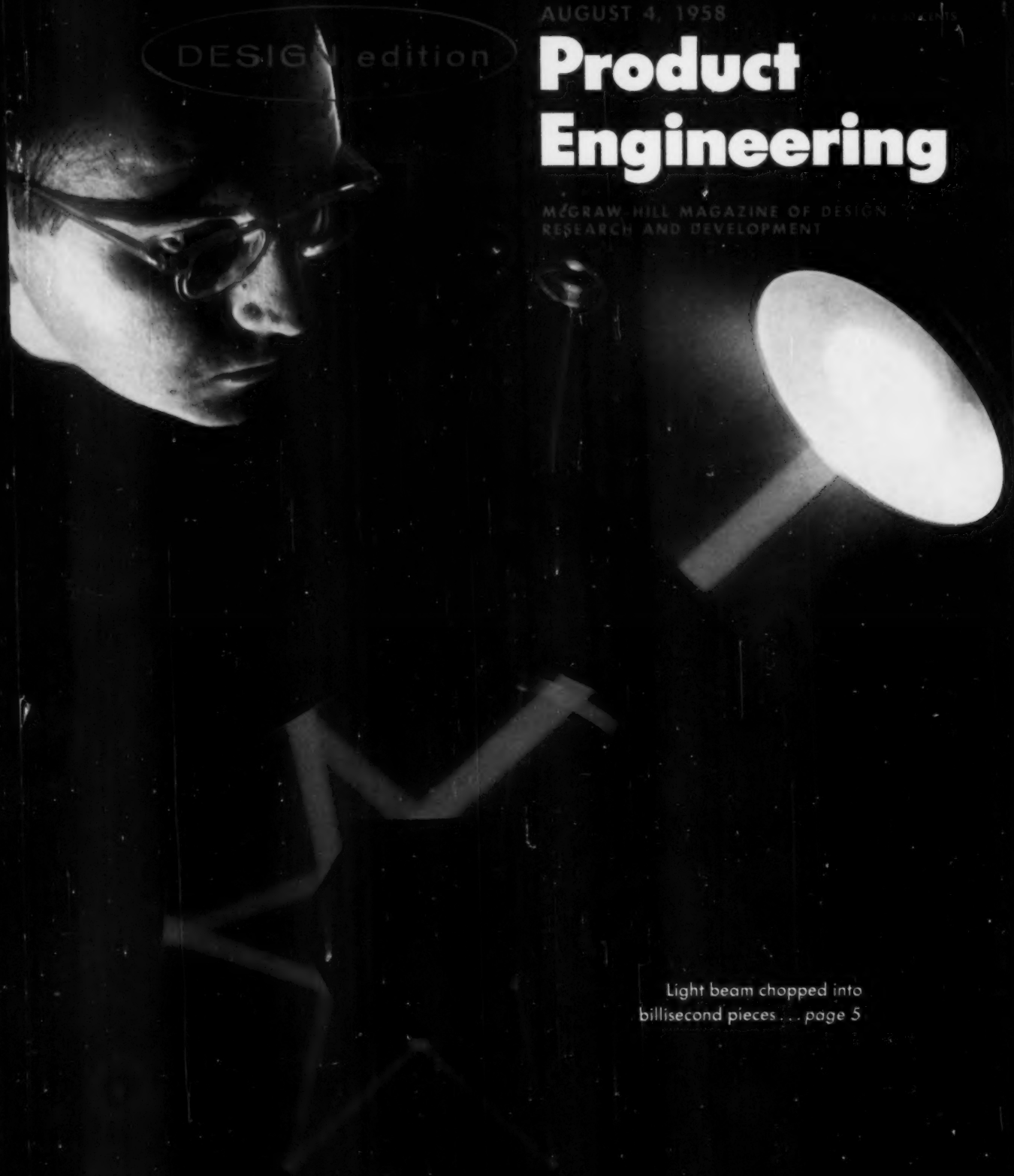
AUGUST 4, 1958

DESIGN edition

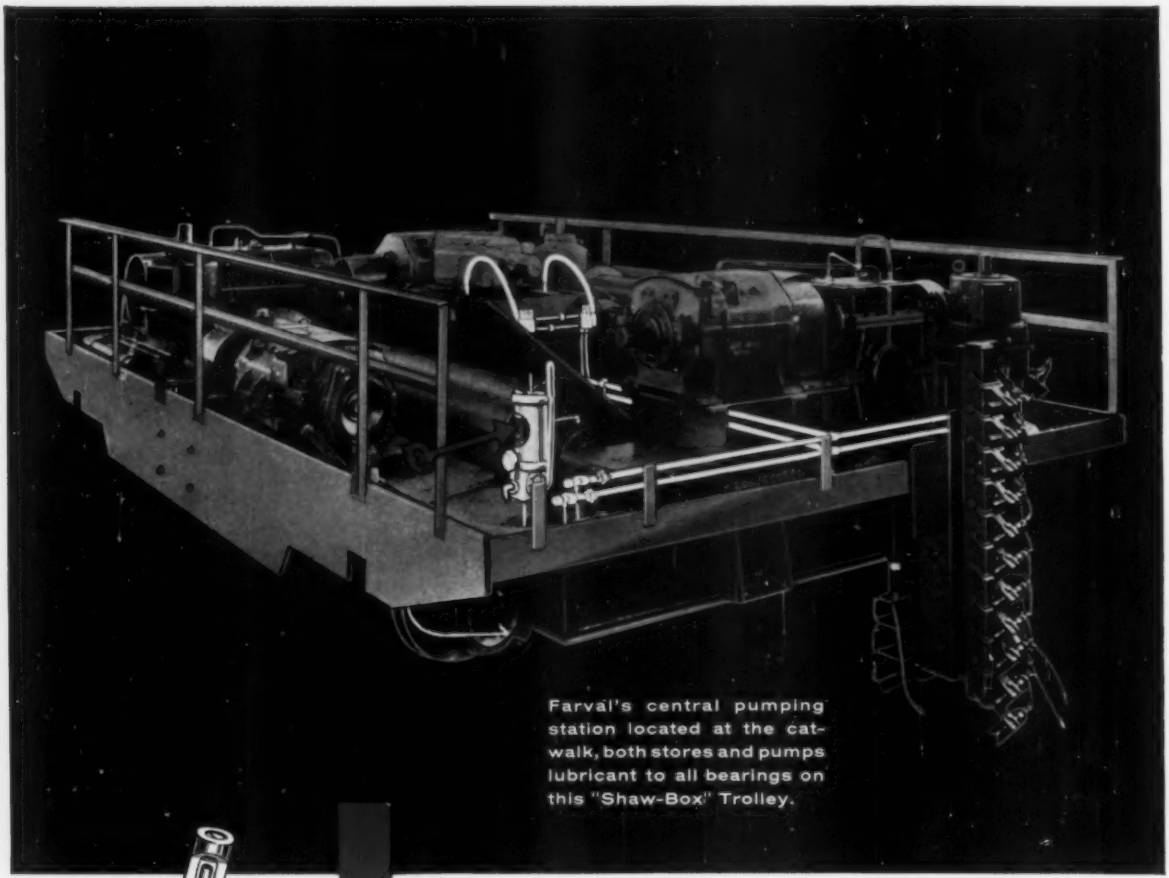
Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

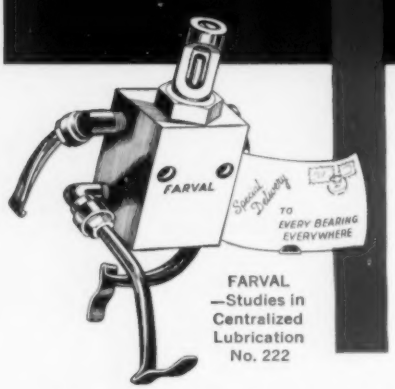


Light beam chopped into billisecond pieces . . . *page 5*

ANALYSIS OF TORQUE-LIMITING DEVICES



Farval's central pumping station located at the catwalk, both stores and pumps lubricant to all bearings on this "Shaw-Box" Trolley.



FARVAL
—Studies in Centralized Lubrication
No. 222

Farval helps 200-ton "Shaw-Box" Crane deliver dependable performance

RUGGED "Shaw-Box" cranes, built by Manning, Maxwell & Moore, Inc., moving plates, slabs or giant ladles in steel plants across the nation are noted for safe, dependable service under extreme operating conditions. One big reason for this performance is proper bearing lubrication . . . provided by Farval.

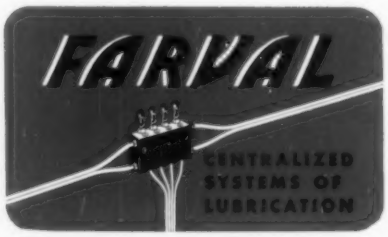
Farval's up-to-the-minute method sends measured amounts of lubricant to all crane bearings from a safe, centrally-located pumping station. Thus the need for men to crawl over the crane with hand grease guns is eliminated.

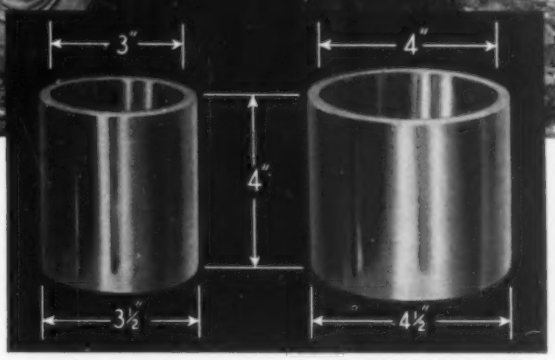
To see how Farval can help you cut operating costs, ask for revised Bulletin 26-S. Write today to The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION

—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.





OILITE

SELF-LUBRICATING BEARINGS

prove a match for top payloads on ATHEY Rear Dump Trailers

Oilite* Bronze Bearings have proven more than a match for the 22 and 34-ton payloads on Athey Rear Dump Trailers.

Oil-cushioned against shocks and impacts, these Oilite heavy-duty bearings have demonstrated that they will withstand years of punishment and still give satisfactory service. They require only infrequent lubrication and help Athey substantially increase the dependability of its hauling units. Yet, Oilite Bearings *cost less* than many other type bearings!

No wonder more and more designers are specifying popular Oilite self-lubricating Bearings for motor vehicles, appliances, engines, power tools, machinery and countless other products.

Contact your local Oilite Engineer today. He'll gladly provide complete design information to help you make your bearing and bushing applications low-cost, dependable and maintenance-free. Look for him in your telephone directory under "Bearings—OILITE" or write direct to Dept. A-8.

TYPICAL PROPERTIES OF SELF-LUBRICATING BRONZE OILITE BEARINGS †

Porosity, %	18-23
Ultimate Tensile Strength, (psi)	18,000
Compressive Strength (psi)	20,000
Elongation, % min. in 1"	10
Brinell Hardness	40

† Other materials and physical properties available.

* REGISTERED TRADEMARK ONLY CHRYSLER MAKES OILITE

the most trusted name in powder metallurgy

SINCE 1929 — OILITE — **AMPLEX DIVISION**

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

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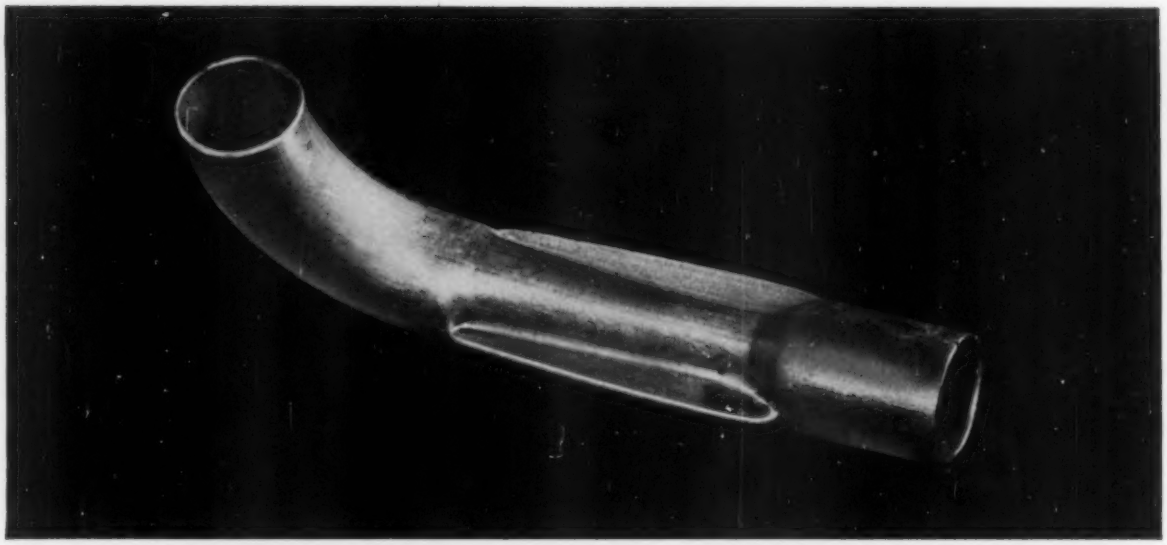


Armco ALUMINIZED STEEL Tubing Cuts Cost of Appliance Parts for Manufacturer

Venturi tubes for gas ranges made of Armco's hot-dip aluminum coated tubing provide resistance to heat and corrosion at less cost

Lincoln Brass Works, Inc., Detroit manufacturer of appliance components cut the cost of gas range venturi tubes by using Armco ALUMINIZED STEEL Type 1 Tubing instead of plated or ceramic coated steel tubing.

The company switched to Armco's special tubing after making a detailed engineering and cost analysis of materials acceptable to AGA for the application. Their tests showed that ALUMINIZED STEEL Tubing assured ample corrosion- and heat-resistance for dependable durability, and made possible appreciable cost reduction.

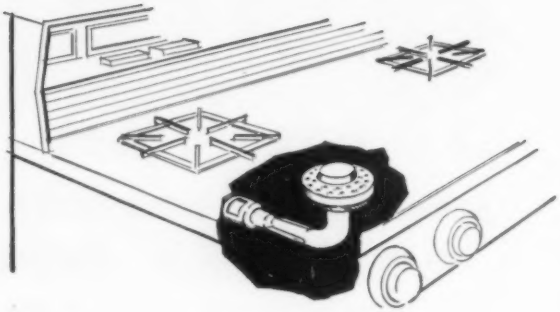
Offers Unique Advantages

Armco ALUMINIZED STEEL Type 1 Tubing gives you all the advantages of light weight tubular construction plus top resistance to a combination of heat and corrosion. Its special coating won't discolor up to 900 F, resists destructive scaling to about 1250 F.

Because of these advantages, unmatched by any other metal tubing in its price class, ALUMINIZED STEEL Type 1 Tubing is widely used for heating elements; truck, tractor and automobile exhaust systems; heat exchanger tubes; flash tubes and similar parts.

Give *your* products an edge on competition with the design-improving and cost-cutting possibilities of Armco ALUMINIZED STEEL Tubing. It's available in O.D.'s from 3/8 to 3 inches, gages from 13 to 20, and special shapes.

For complete information on properties and available sizes, just fill out and mail the coupon.



New steels are born at Armco

ARMCO STEEL CORPORATION, 2518 Curtis St., Middletown, Ohio

Send me complete information on Armco ALUMINIZED STEEL Tubing. We are considering it for_____

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COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

AUGUST 4, 1958 Vol. 29, No. 31

Economy in a Small Gas Turbine 38... Hans Ziebarth, AiResearch Manufacturing Co.
Its small size and light weight promise increased use in many commercial applications. And when its exhaust heat is put to work it rivals the diesel in fuel cost.

Those Pipe Fittings that Swivel * 40... G. M. Bagnard, Chiksan Co.
They are often the best answer where the flexible joint must be as strong as the pipe. Here's your guide for choosing between swivels and hose-type connections.

How to Predict Gear-train Efficiency 44... E. E. Shipley, General Electric Co.
The sliding action of involute-gear teeth causes a power loss; compute it from new formulas and test data given in this article.

Design Features in New Products 46... Electronic finger checks drills; resistor smooths lift-truck drive; Moscow's bus built like ours; control panel speeds the foreman too.

Torque-limiting Devices—Which Type? * 50... R. A. Bareiss and P. A. Brand, Lessels and Associates, Inc.
Hydraulic . . . magnetic . . . mechanical . . . electromechanical? In text and table, authors analyze 17 conventional and newer ways to prevent motor overloading and strain on equipment

The Latest on Silicone Rubber Sponge 54... J. C. Walton, Chase-Walton Elastomers, Inc.
Now tolerances can be predicted and the percentage of rejects cut—with better sponging grades, sharper process controls, and special reinforcing techniques.

Stress Corrosion in Metals 56... Dr. E. H. Phelps, United States Steel Corp.
Stress plus chemical environment can make it tough for some alloys to resist cracking. Article covers characteristics of such damage, and design steps that will head it off.

DESIGN FILE

13 Ways to Couple Shafts 60... Federico Strasser, Mankewitz and Strasser, Ltd.
Illustrates 8 allowing axial play; 5 giving angular play.

Figuring Deflections of Elastically Supported Cantilevers 63... T. F. Callahan, United Shoe Machinery Corp.
Formulas and diagrams for 8 beam mountings.

DEPARTMENTS

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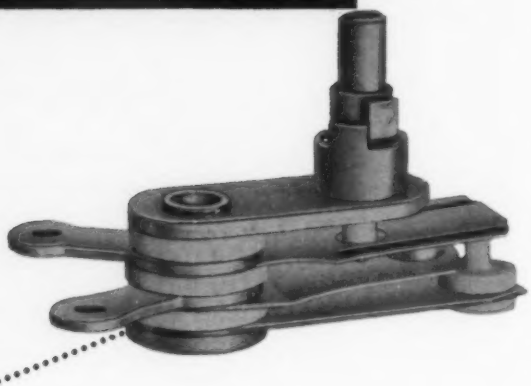
FOR SKILLETS, SAUCEPANS, GRIDDLES*



Type S above, Type H below. Other designs available.

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No wonder leading manufacturers of electric appliances specify Stemco thermostats. For Stemco thermostats give long-life reliability that eliminates service headaches . . . are quickly, easily installed . . . are competitively priced. Our application engineering service is eager to help you solve your thermostatic control problem, whether it involves design, production or cost. Try us *now*.

STEVENS *manufacturing company, inc.*

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THERMOSTATS

CIRCLE 103 READER SERVICE CARD

Other appliances, too, such as percolators, inhalers, air heaters, fans, steam and flat irons, roasters, fry kettles, refrigerators, butter warmers, waffle irons, electronic and avionic applications.

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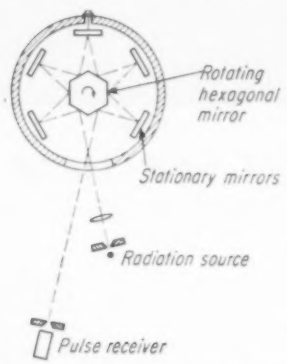
Interesting to Note . . .

Light Chopper

A method for mechanically chopping a beam of light into pieces only a few billionths of a second in duration has been developed at Westinghouse Research Labs by Dr. Max Garbuny, T. P. Vogal, and J. R. Hansen. The "light chopper," pictured on our cover, produces sharply defined, fast pulses of light to test the speed with which electronic devices respond to light and other forms of radiations. Previously, mechanical "light choppers" have been able to turn light pulses on and off no faster than about one-millionth of a second, which has been relatively slow. The new chopper was designed as a substitute for the usual methods, which produce short pulses of light by means of electrical discharges or other electrical means.



A beam of light is reflected from a six-sided rotating mirror, which is surrounded by five stationary mirrors proportionally spaced around the inner surface of a metal cylinder. The light beam is repeatedly reflected back and forth between rotating and stationary mirrors until it flashes past an output slit traveling 12 times the mirror speed. The slit chops it into pulses lasting only a few billionths of a second.

The device has proved of particular value in researching the response of sensitive materials to infrared since this radiation cannot be broken into fast pulses by any other method.

Turbine History

With our modern heat engine called the gas turbine (see page 38), the problem is greater efficiency. True, the higher its top temperature, the higher its efficiency. And it is relatively simple to get fuels which will generate very high temperatures. For example, powdered aluminum burns at 6300 F; powdered beryllium at 8100 F. But materials are not available that will withstand these high temperatures. Hence, top efficiency of the engine is limited

(Continued on page 7)

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WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

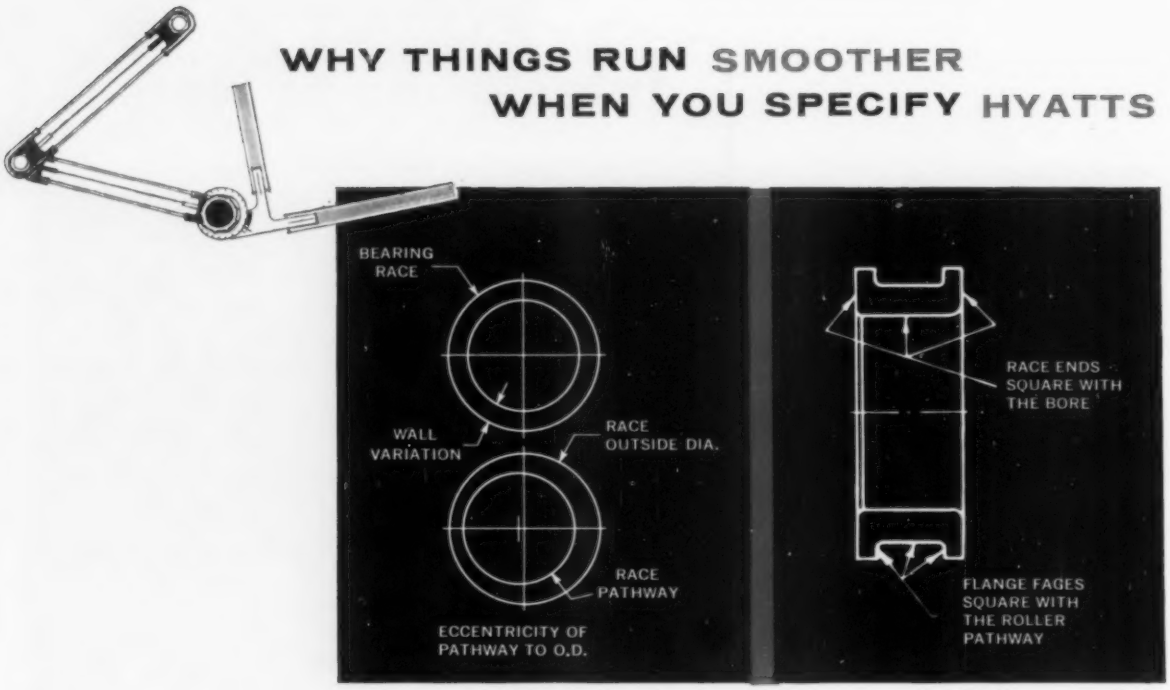


FIGURE 1 FIGURE 2

CLOSE CONTROL OF INTERNAL DIMENSIONS MEANS LONG, TROUBLE-FREE BEARING LIFE

The running accuracy and smoothness of a roller bearing is governed by the tolerances of its internal dimensions and clearance. Internal dimensions include concentricity of race diameters and squareness of all radial and axial surfaces, as briefly explained at right.

Because the internal dimensions of HYATT Hy-Roll bearings are so closely controlled, HYATTS run smoothly and quietly, last longer, and prevent equipment trouble due to excessive heat and vibration. You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; and Oakland, California.

Concentricity of race diameters is usually defined in terms of wall variation (Figure 1) of the individual races, and radial run-out of the assembled bearing. Squareness of race and roller ends and flange faces is vital to prevent roller skewing with consequent heating and noisy operation. Figure 2 indicates the race surfaces which must be square with each other within minute tolerances depending on the grade of the bearing. The roller ends must also be square with the diameter for the same reason as above. End square tolerances are usually less than .001" for the most frequently used sizes.

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

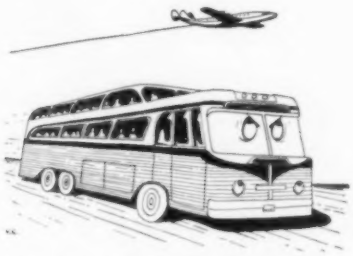
1908–1958

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

and to pass that limit means waiting for metallurgy to catch up.

History of this turbine goes back to the philosopher Hero who, in 130 B.C., designed a toy turbine with small symbolic figures mounted on the wheel. Air heated in the vertical, tubular shaft caused air to flow in radially placed tubes. The resulting rotation was caused by an impulse effect. "Gadgets" operating on the same principle are found in hobby shops today. However, it was not until 1791 that the patent of John Barber contained the first recorded description of a gas turbine. It also described the constant-pressure cycle, which is used in most modern gas-turbine powerplants. In 1895 Charles Gordon Curtis was granted a US patent for a gas turbine, and in 1903 General Electric started research on an exhaust-driven turbo-supercharger for aircraft engines.

Many have experimented with gas turbines since, but credit is given to Frank Whittle, an Englishman, for having developed the first practical aircraft propulsion unit powered by thermal jet reaction using a gas-turbine compressor unit. He received the patent in 1930, and the first plane was built in 1937.



Buses Are Here to Stay

Although Boeing and Douglas now are about to have their commercial jet airliners coming and going from every major airport, let's not forget the traveler who moves by "grounded" transportation. One would think that with faster and quieter planes, long-distance bus travel would become as obsolete as the horse and wagon. Actually, more people are riding more miles on buses today than ever before. Abroad, our editor reports that Russia's largest automobile works is turning out buses at a rate of 25 a day. These Russian buses are described in detail on page 48.

Before 1920, when only 10,000 buses were registered in the US, the most notable bus owners were persons who had once been engaged in operating livery stable service. They were quick to recognize the demise of the horse and began designing special motor coaches and jitneys to accommodate more passengers. As bus service grew, road building also improved until, by 1930, the registered number of commercial buses was almost 100,000.

Perhaps the most important influence upon the American scene was the fact that children could now go to and from school by a motor bus. School districts with small population consolidated to form larger townships. Bigger and better schools resulted and the "little red school house" receded into history.

Yankee Traders

Shrewdness has long been considered one of the prime attributes of the "Yankee trader." In early days barter between North and South relied on a strong sales technique. Even this summer, tourists to New England will return home with "genuine" grandfather's clocks and "original" cobblers' benches in "like new" condition. The Yankee selling method hasn't always been based on shrewdness; once it was purely accidental.

Chauncey Jerome was a true Connecticut Yankee. He had entered the clock business in the early 1800s and by his own inventiveness had designed an inexpensive clock with stamped gears. The efficiency of his gears (for modern-day efficiency calculations—see page 44) and the fact that salt air could not warp them made his clocks ideal for the foreign market. Since his son Chauncey, Jr. was in England he decided to ship a large consignment to him on a trial basis. When the clocks arrived, British customs officials could not believe a brass clock could possibly be valued as low as $1.50—the retail price marked on each timepiece. They assumed the price tag was a Yankee scheme to avoid the tariffs since English clocks were more than twice as expensive.

To teach the Jeromes a lesson the customs people confiscated the entire shipment, paying $1.50 per clock. Elder Jerome was overjoyed. He had disposed of his stock without a marketing problem. The next shipment was also confiscated at $1.50 per clock. Custom officials became puzzled that a New England clock manufacturer could actually afford such a loss, then send another shipment with the same price tag attached. The third consignment convinced the officers that a Yankee had won again.

—Benedict A. Leerburger Jr.

Index to Volume 29 Now Ready

A 16-page printed index of editorial content in all issues for the first six months of 1958 is now ready. Copies may be obtained by circling No. E35 on one of the Reader Service Cards bound inside the back cover of this issue.

Hereafter, the Index will be issued twice each year, in July and January, and copies will be supplied on request without charge as long as the supply lasts. A limited supply of the Index for Volume 28 is also still available on request.

FOR THE MACHINERY PART

THAT TAKES THE BEATING

HAYNES Alloys *will do the job!*

An example: Knives tipped with HAYNES STELLITE alloy 6K whirl at 15,000 rpm as they strip corn cobs of their kernels. Not only do they resist corrosion, but canners report that they stay sharp six times longer than previously used cutting edges.

This is typical of the results reported by design and production engineers that specify HAYNES alloys. Parts made of these alloys are operating successfully in thousands of plants – under the roughest service conditions.

If you need a tough metal part, investigate HAYNES alloys. There are more than 15 of them from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

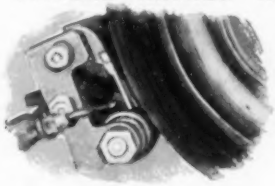
Kokomo, Indiana

UNION CARBIDE

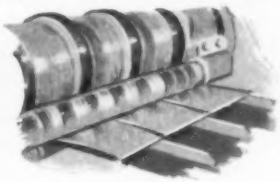
The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS

Metal-cutting saws, made of HAYNES STELLITE alloy sheet, over 20 in. in diameter slice the tops off copper ingots.



Trimming 3000 auto tires without resharpening is routine for knife blades made of HAYNES STELLITE alloy.



Slitter knives tipped with HAYNES STELLITE alloy trim miles of sheet metal in a can making operation.

Doctor blades made of HAYNES STELLITE alloy assure long service life trimming abrasive cake from filter drums.

MICRO SWITCH Precision Switches

NEW

Actual Size

We've Miniaturized the Subminiature!

WEIGHT: *1 gram . . . 28 switches to the ounce . . . over 430 to the pound.* SIZE: *.500" long, .200" wide, .350" high.*
CUBIC CONTENT: *.035 cubic inches.* ELECTRICAL RATING: *5 amps-250 vac, 30 vdc. SPDT.*

After a long period of laboratory development, MICRO SWITCH announces this new, highly miniaturized precision snap-action switch and a complementary line of actuators.

We call it the "Sub-subminiature!"

This new "SX" basic switch represents an entirely new set of answers to the space-weight problems in dependable precision switching. It combines new small size with more than ample capacity for wide usefulness, meeting the pressing demand for miniaturization combined with reliability.

In its exacting development, many problems of design, testing and quality control presented themselves. However, 23 years of experience proved of immense value. As a result, a new standard has thus been set by which all precision switches must be measured.

This broad experience can prove of equal value to you. Send for more information about this new switch. Request Data Sheet No. 148.

—•—

MICRO SWITCH...FREEPORT, ILL.
A division of Honeywell
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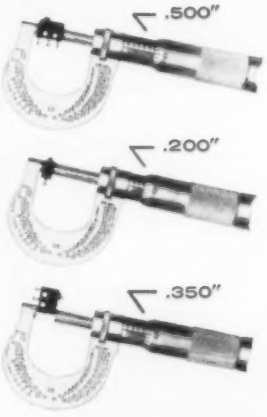


Honeywell
MICRO SWITCH PRECISION SWITCHES

The two-word name MICRO SWITCH *is* NOT *a generic term. It is the name of a division of Honeywell.*

ACTUATE

MORE EASILY...
EFFICIENTLY...
ECONOMICALLY

ROLLED THREAD

SAGINAW b/b SCREWS

Make Your Product

- **easier to produce**
- **easier to operate**
- **easier to sell**

The secret lies in a new anti-friction principle—steel balls recirculating in closed-circuit raceways. They permit Saginaw b/b Screws to change rotary motion into linear motion with over 90% efficiency and 4/5 less torque than Acme screws. Result: Saginaw b/b Screws save manual effort or electrical power; they permit space savings—smaller motors and gear boxes; they provide more dependable performance; more precise positioning; more temperature tolerance and more lubrication latitude.

SEVEN STANDARD SIZES REDUCE COSTS

Top-quality Saginaw b/b Screws are the only kind stocked in seven standard commercial rolled thread sizes, cut to desired length, for low cost and fast delivery. Or you can order custom machined screws for critical or extreme precision applications. Saginaw has successfully built screws from 1½ inches to 39½ feet long—⅜ inches to 10 inches diameter.

MANY TYPICAL APPLICATIONS

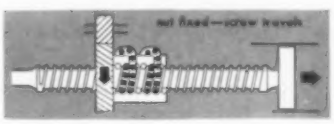
Saginaw b/b Screws have been applied to automatic garage doors, automobile seat adjusters and window lifts, barber chairs, hospital beds, bumper jacks and circuit breakers. Or they can be used for heavy industry equipment like die table positioners, drill presses, lift trucks and welders.

Automatic Garage Door lifts and lowers easily and smoothly when actuated by Saginaw b/b Rolled Thread Screw.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS

When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



LET SAGINAW'S EXPERIENCED ENGINEERS HELP SOLVE YOUR SPECIAL APPLICATION PROBLEMS • JUST WRITE OR PHONE US—NO OBLIGATION

Saginaw ball bearing Screw

SAGINAW STEERING GEAR DIVISION • GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

Formability—In days of old, when knights were bold, they also were smart. When their very lives depended on a tool or a weapon, they made sure it was made from steel. It could be a great claymore, hefty enough to behead a horse; a bright suit of armor that would turn the Saracen's arrow; or an ornamental castle gate, strongly made to frustrate the assassin.

They wanted steel because it was strong. They could *use* it because it was formable. Truly, there is no economical metal in all the world that can approach steel's combination of strength and formability.

With the near-magic of heat treating, you can soften steel and form it, then harden it to make it strong, then temper it to make it tough. Or form it cold. Use bending, flanging, deep drawing, spinning, cold heading, die drawing, rolling, wiper forming, draw rolling, stretch forming or bumping. In fact, it's hard to imagine any forming operation that cannot be performed on steel.

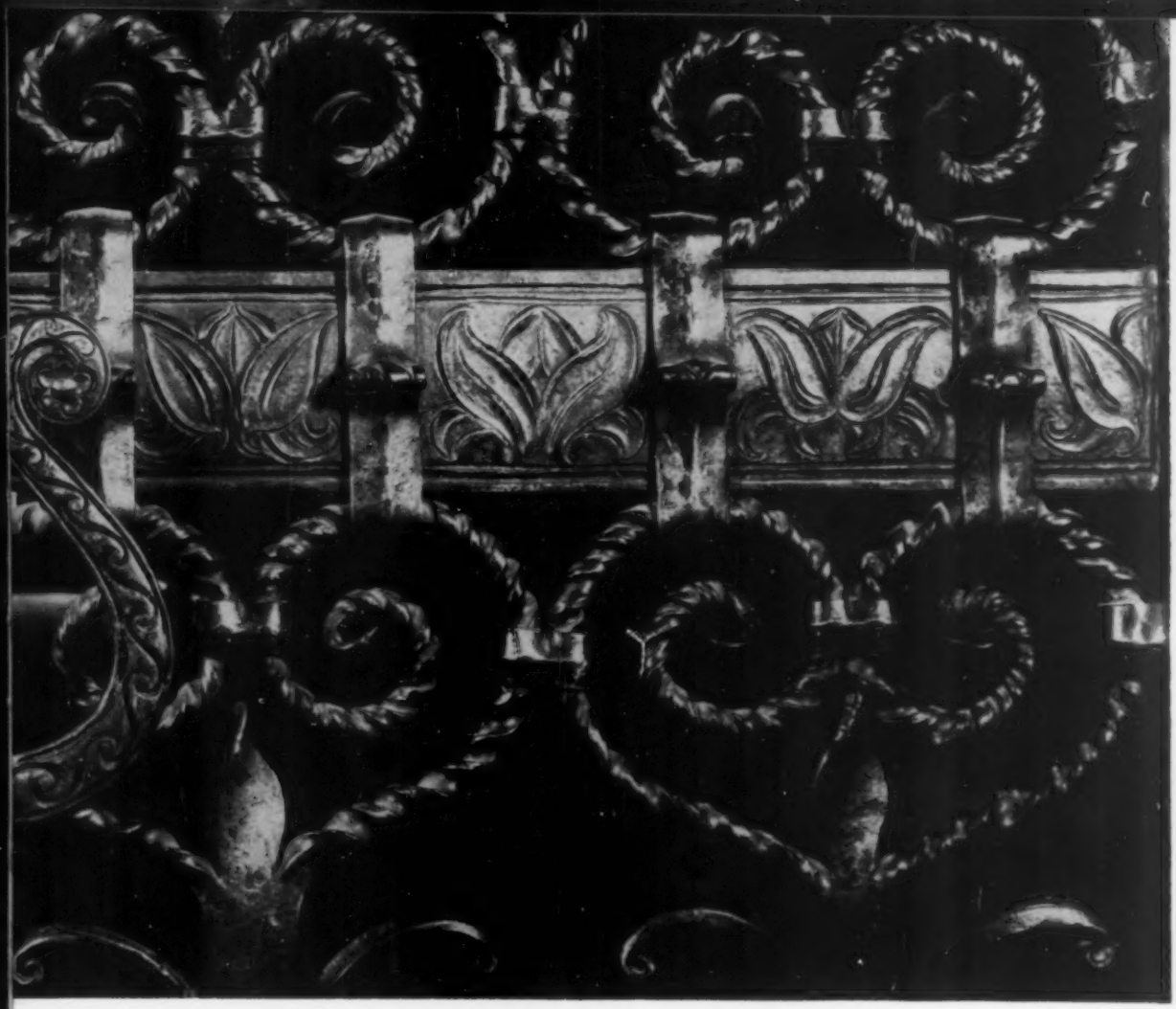
Fortunately, there are hundreds of different kinds of steel; and they all act differently in the fabricating shop. Everything you do to steel alters its *forming* properties, and every forming operation alters its physical properties.

The aim of the product designer is to find a steel that can be properly formed, that has the right strength, toughness, corrosion resistance, weldability or other characteristics required . . . at the most favorable cost. If you have a design problem and the comptroller is looking over your shoulder, take hope from this idea: there is one "best" steel for any design application. You can be sure of finding it among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless Steels.

If you need help in making your selection, ask a company that has produced well over a billion tons of steel, and has spent hundreds of millions of dollars to learn more about this most versatile of man's metals. Of course that means United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel



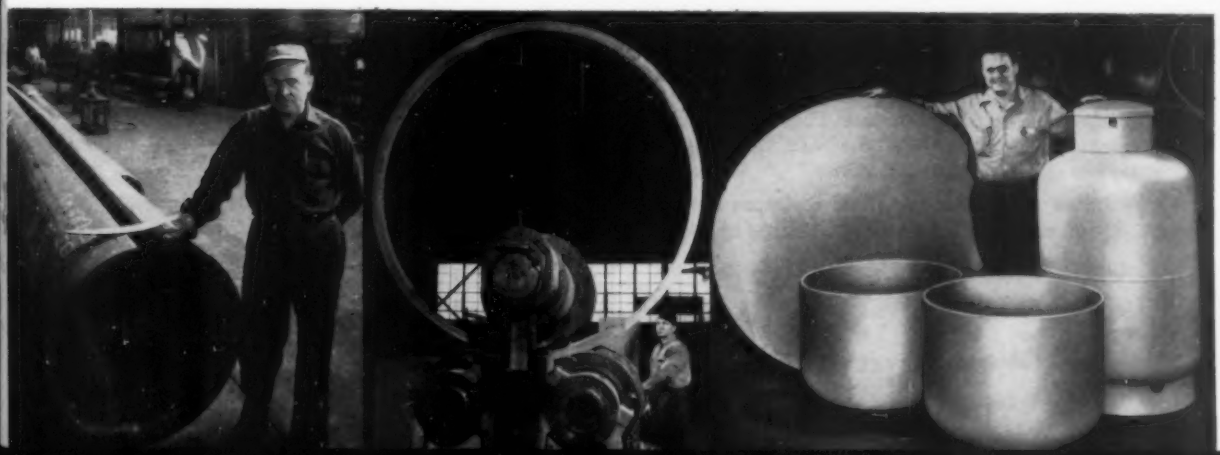
STEELS FOR DESIGN

Lower Left—Problem: Build a power shovel dipper stick with greater strength and shock resistance. Solution: Bucyrus-Erie Company designed a tubular stick made from USS "T-1" Constructional Alloy Steel. Payoff: The "T-1" Steel plates were easily cold-formed into a tube and butt welded. The tubular design and stronger steel assured great strength and shock resistance, and easy fabrication.

Lower Middle—Problem: Produce strong, heat resistant, corrosion resistant jet engine rings—*economically*. Solution: Alloy Manufacturing Company carefully selected a grade of USS Stainless Steel. Payoff: The rings resist heat and corrosion and they are economically roll-formed because the Stainless Steel is formed on "carbon steel rated" equipment.

Lower Right—Problem: Design a pressure tank that is just as strong but lighter than conventional carbon steel tanks. Solution: Manufacturer selected USS MAN-TEN High Strength Steel. Payoff: MAN-TEN's greater strength (50% higher yield point than carbon steel) permitted design of a thinner-walled tank that is 24% lighter. And because MAN-TEN is highly formable, the tank is economically produced by cold press forming of circular blanks into seamless shells, 29″ in diameter and 24″ deep.

USS, "T-1" and Man-Ten are registered trademarks



Their aim . . .
to give you MORE than a motor

Tackling the Future—a job for Century's Junior Board

Carefully selected middle management men hold free-thinking, no-holds-barred discussions on Century Electric problems. Once a month, junior executives from production, design, finance, purchasing and sales get together to help build more benefits into the Century motor line. These benefits mean that when you do business with Century Electric, you get *more* than a motor.

The Junior Board was organized to insure the continuity of new design and manufacturing ideas that have been the hallmark of Century Electric progress for over 50 years. The results are new, better and improved customer services, products, production methods and design.

These are tangible benefits that Century Electric customers have learned to expect. In motor needs covering 1/20 hp to 400 hp, they know they'll get *more* than a motor from Century Electric. For more information, contact your local Century Electric Sales Office or Authorized Distributor.

CENTURY ELECTRIC COMPANY

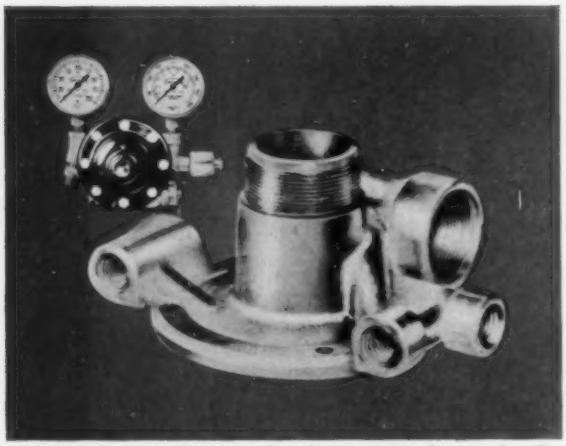
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

CIRCLE 109 READER SERVICE CARD

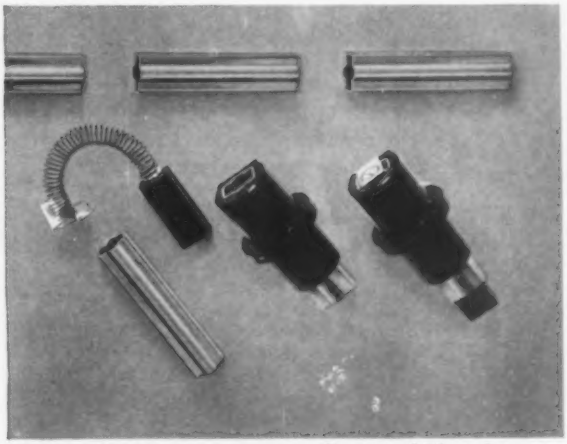
Century

58-4

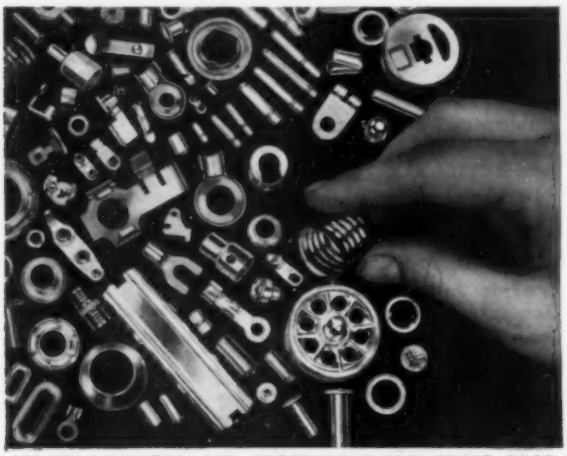
TAKE A FRESH LOOK at the way you are fabricating metal parts. Cost-cutting possibilities are almost unlimited with these Anaconda pre-formed mill products and press products.



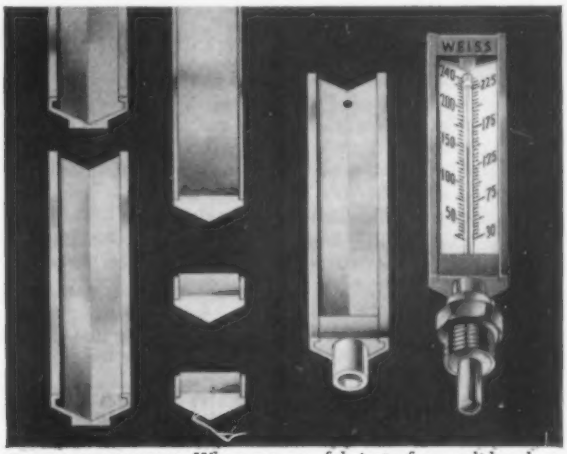
DIE-PRESSED FORGINGS, made of twice-wrought metal, offer superior uniformity, denseness, accuracy. *Savings:* replace more costly built-up assemblies—often are less in first cost than sand castings—require minimum surface machining to size—simplify secondary operations—lower tool cost—lower finishing cost.



SPECIAL-SHAPE TUBES can, as in the case of Electrolux, save several steps in arriving at a finished part. Brass electric-motor brush holder (above) is cut economically from long lengths of tube pre-shaped to accommodate both brush and spring. Uniform accuracy of all dimensions helps provide good brush stability.



MULTIPLE-PLUNGER AND PROGRESSIVE-TOOL-PRESS PRODUCTS are cutting costs throughout industry—often over 50%. Main reasons: The American Brass Company's complete design engineering service, long experience, specialized production equipment, a big selection of stock tools. Metals: copper, copper alloys, nickel, iron, steel, stainless steel, or aluminum.



EXTRUDED SHAPES. Wherever you fabricate from solid rod or bar—or castings—consider savings in machining, tooling and scrap by use of extruded shapes. Albert A. Weiss & Sons substituted two extruded shapes, above, for a sand casting—cut cost of thermometer case 41%, got an additional 30% saving in assembly because of consistently uniform dimensions.

HERE are four immediate approaches to cutting costs. Re-evaluate your designs and fabrication methods with these short cuts to finished products in mind. Wherever you spot a possible saving, send a sample, drawing, or description—with the quantity you need, the metal or properties you require—and ask for a quotation. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ontario. 5853

DIE-PRESSED FORGINGS • SPECIAL-SHAPED TUBES
EXTRUSIONS • FABRICATED METAL GOODS

products of

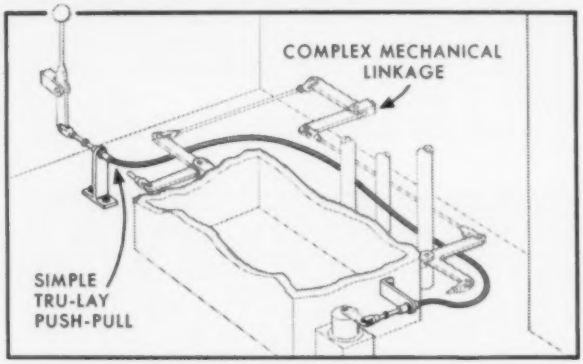
ANACONDA®

Made by The American Brass Company

with TRU-LAY PUSH-PULL controls, you can---

MAKE HUNDREDS OF PRODUCTS MORE USEFUL, EASIER TO SELL

Tru-Lay Push-Pull controls provide positive remote action over long or short distances. Because they operate while flexing, they can snake around obstructions. They are ruggedly constructed, easily installed and operated, and are sealed against dirt and moisture. Push-Pulls are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Linkages, on the other hand, are complex. They're made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Here's Why Push-Pull Controls Simplify Design, Give Better Performance

Long Life—We have never heard of a Tru-Lay Push-Pull wearing out in normal service.

Dependable Operation—Top performance under the most adverse conditions...in temperatures ranging from −70°F to the high levels of jet engine operation...in wet locations...in abrasive atmospheres.

Freedom from Trouble—Inner working member is fully protected by tough, flexible conduit...lifetime factory lubrication...sealed against entrance of dirt, moisture, and other foreign matter...cold swaging of all fittings.

Accuracy—Built to the most exact standards of quality and precision. On automobile pushbutton transmissions, for instance, Push-Pull controls provide five positions with a total movement of only .560".

Capacity—Push-Pull controls will handle jobs with as much as 1,000 lbs. input, 150 feet or more from the control point.

Adaptability—Push-Pull controls can be adapted to countless applications. Standard anchorages, fittings, and heads meet almost any requirement, and modifications can be made to fit special situations.

Design Engineers Report on Benefits

Saves Time, Labor, and Material
"We use Push-Pulls to operate clutch controls on the main power unit, feed conveyors, and delivery conveyors...and we save the time, labor, and material required for planning and engineering the old linkages."

Greater Flexibility of Design
"Push-Pulls give us flexibility in locating the hydraulic control valve in relation to the operator's position."

Cost Less to Install
"They are easier and less expensive to install than linkages for remote control of power take-off."

Solution to Tough Problem
"Can be installed where straight rods are impossible."

Eliminates Maintenance
"No maintenance whatsoever; not even lubrication is required."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods, and other lost-motion devices for remote control of hydraulic valves."

Provide Accurate Control
"We get minimum backlash because the cable is designed to close tolerances with minimum drag and lost motion."

Push-Pulls Can Help Solve YOUR Remote Control Problems

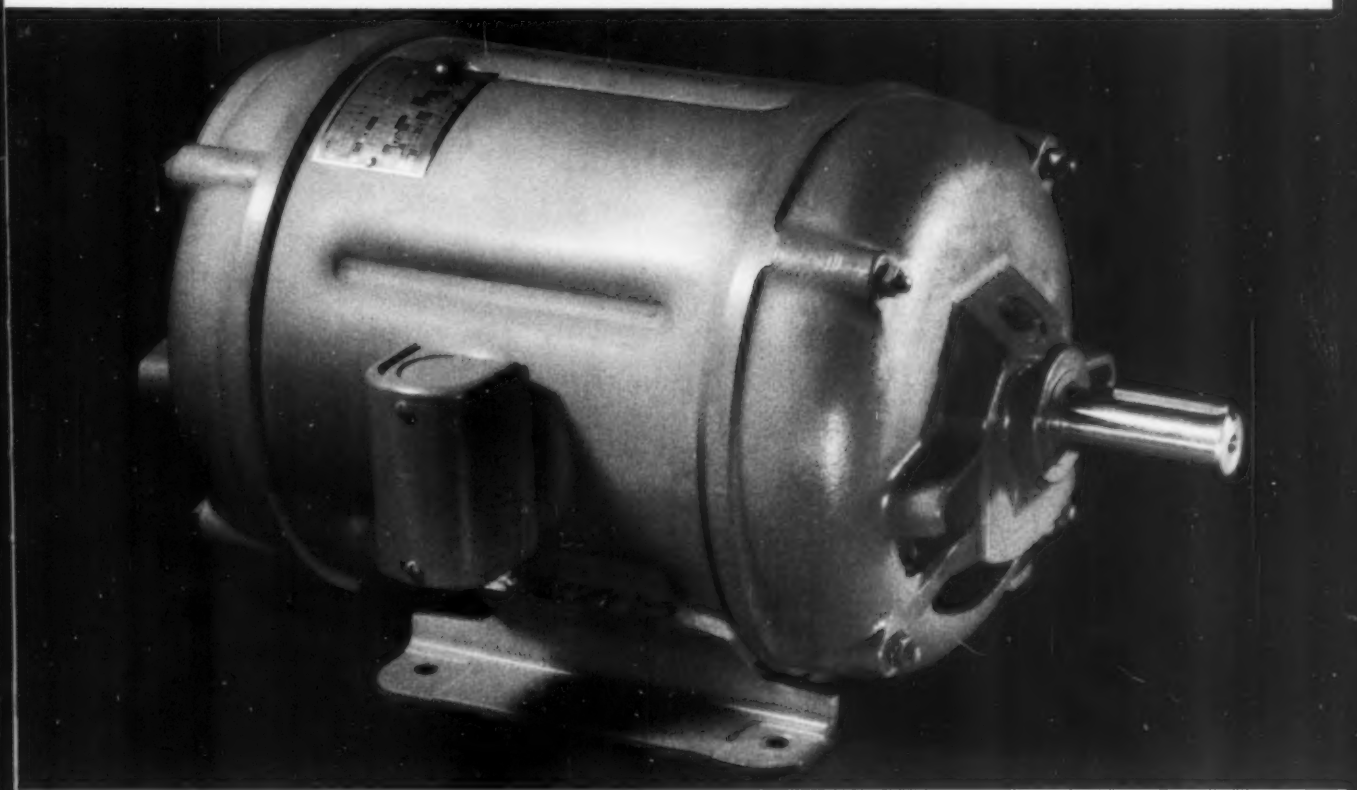
Push-Pull controls are solid as a rod and flexible as a wire rope. You can use them in the electrical, hydraulic, and pneumatic systems on construction equipment, on farm implements...almost *anywhere* convenient remote control is desired. For complete details on how you can use them, write for a copy of the Push-Pull Data File. It contains 7 bulletins which describe in detail the operation of Push-Pulls, their applications, features, and advantages. Our engineers will be glad to help you make Tru-Lay Push-Pull controls a part of your product.

Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

ACCO

601-E Stephenson Bldg., Detroit 2
2216-E South Garfield Ave., Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

Got a Real Tough Starting Problem ?



Single-phase Type RA ½ to 15 hp.

Wagner Repulsion-Start Induction Motors start heavy loads with low current

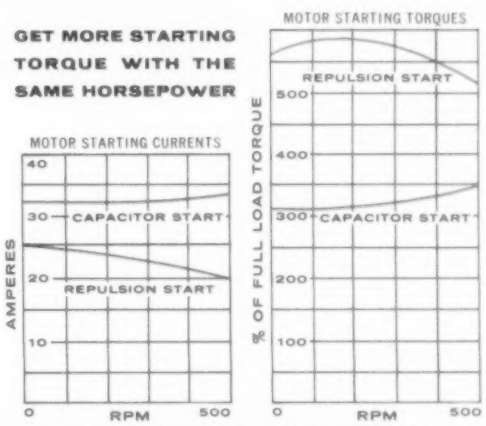
The Wagner Type RA is the work-horse of the single-phase motor field. It combines high starting torque for quick, easy starts with low starting current and minimum light flicker. It has a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough single-phase applications with Wagner RA Motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Bulletin MU-220.

Wagner Electric Corporation
6400 Plymouth Ave., St. Louis 14, Mo.
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

GET MORE STARTING TORQUE WITH THE SAME HORSEPOWER



ONE HP, 1750 RPM, 60 CYCLES, 230 VOLTS

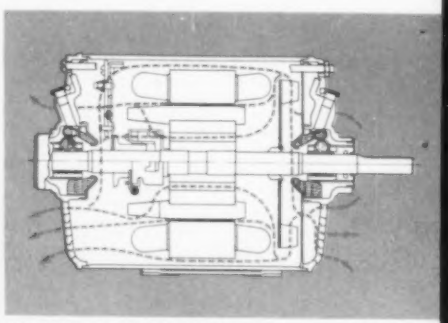
Integral Ratings, 1-5 hp are available in the latest NEMA Frame Sizes

H. P.	OLD FRAME SIZE	PRESENT FRAME SIZE
1	203	182
1½	204	184
2	224	213
3	225	215
5	254	254U

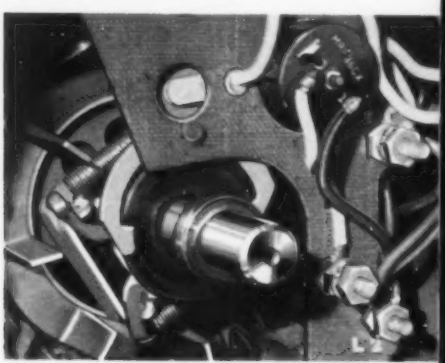
4 pole (1750 RPM, 60 cycle and 1450 RPM, 50 cycle) ratings are interchangeable in mounting dimensions with capacitor start motors of the same ratings.

Got a Normal Starting Application?

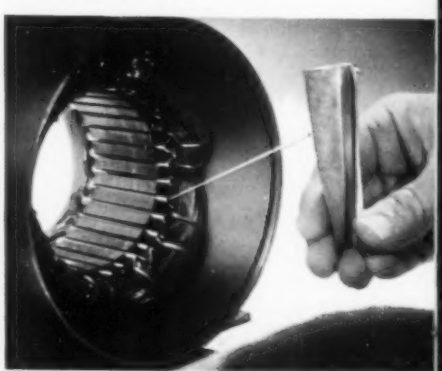
Single-phase
Type RK
⅙ through 5 hp.



EFFICIENT COOLING SYSTEM—The improved ventilating system used in these motors directs a large volume of air through the motor to effectively reduce temperatures and add to motor life. Cross section above indicates direction of air flow.



QUICK BREAK SWITCH—The starting winding and capacitor are disconnected from the line by this Wagner Switch—test-proved to make more than a million makes and breaks . . . the equivalent of two starts per hour for 50 years.



MYLAR* INSULATION — Mylar-paper laminated slot insulation gives top protection against moisture, adds thermal stability, to give more application versatility and longer life when unexpected overloads occur.

*DuPont Trademark

WAGNER CAPACITOR-START MOTORS provide dependable starts... long troublefree life

Here's the single-phase general purpose motor that gives more horsepower with less bulk—is rugged enough to permit direct mounting, compact enough to fit in tight spots. Available with sleeve or ball bearings — with rigid bases or with resilient mountings for exceptionally quiet operation.

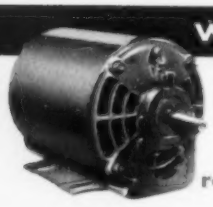
ALL-ANGLE OPERATION

The sleeve bearing design in fractional hp ratings, has a positive lubrication system that permits operation in any position. All angle mounting can mean important savings in initial costs to manufacturers—can help the design engineer in a tight spot.

You can get these motors from leading motor distributors in your community and from Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details.

Wagner Electric Corporation
6400 Plymouth Ave., St. Louis 14, Mo.
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

WAGNER "48" SPLIT PHASE MOTORS . . . 1/6, 1/4, 1/3 hp.



for low starting torque requirements

If you need a small fractional horsepower motor for use on fans and blowers or on a wide variety of easy-to-start machines and appliances, you can't beat the Wagner "48" Type RB Motor. It offers all the advantages of the Type RK described above, with the exception of high torque capacitor starting. This smaller, lighter, limited use motor can solve many application problems economically.

WM58-6

DEVELOPMENTS TO WATCH...

Octane requirements can be held down . . .

. . . and spark knock controlled by proper choice of engine oil, say R. H. Perry, Jr., and H. V. Lowther of Socony Mobil's R & D lab. Recent tests at S-M indicate that a reduction of at least 2.5 units in stabilized octane number can be achieved by choosing engine oils that will minimize combustion-chamber deposits. They used an oil that was admittedly "unrealistic from a commercial standpoint." But their results indicate that continued work along these lines would be well justified.

Oil selection may also help solve a new engine problem, one that's beginning to assume alarming proportions as compression ratios climb toward the decade mark. This is engine "rumble," a loud and ugly noise which, they say, is encountered to a limited extent in several 1958-model cars and appears to be "a formidable hurdle that must be overcome before compression ratios can continue their upward trend."

Rumble is believed to be caused by unduly high rates of energy release coming from too rapid burning of the fuel-air mixture. This may, they say, result from multiple ignitions of the charge, traceable to overheated combustion-chamber deposits.

There is also evidence, as reported by W. M. Wiese of GM at the SAE summer meeting, that combustion chamber design and, of course, type of fuel used, make a big difference here. Engines operated on fuels with a low aromatic content, aided by special ignition control additives, show a significantly lower tendency toward surface ignition and rumble, he notes, and predicts that decreases in octant requirement of as much as 4 units may be possible by this means.

New reactor type . . .

. . . to be explored by General Dynamics Corp. for the AEC and Maritime Administration, will connect a gas turbine to the nuclear heat source. High-pressure gas, heated by, and used as a coolant for the nuclear reactor, will be fed into the turbine, where it will give up its heat energy as it expands, will then be recompressed and returned to the reactor. GD emphasizes this is only an exploratory investigation. High-temperature elements, controls, coolants, and turbine machinery will all have to be developed; so "construction and test operation of a prototype ship-propulsion plant are dependent upon successful completion of development work." That may take several years.

Shorts are short-circuited . . .

. . . by this electronic tube-tester say Chance Vought engineers. It combines in a single pushbutton-operated device a whole group of tests previously performed manually and individually; and, says VC, "the rejection rate on most types of tubes is actually reduced by eliminating human judgment factors."

The "old" method for testing tubes was to whack them over the head with a mallet and check their response with meter and earphones.

The tubes still get thumped with the new machine—but it's done accurately and automatically, with a force of 10 g. The signal created by the blow is amplified, integrated, and differentiated and compared with present limit values (standard computer-type circuits are used) and the tube is checked for electrical leakage—all in a matter of 10 sec. Red lights glow on the panel to alert the operator when defective tubes are found.

Electronic tube tester takes advantage of computer-type components; puts another manual operation on an automatic basis. Chance Vought engineers designed it.

DEVELOPMENTS TO WATCH...

Stronger, more abrasion-resistant rubber products . . .

. . . can be produced by blending-in small amounts of linear polyethylene, Phillips Chemical Co. researchers report.

By adding 10% or less of the new material (*PE—Nov. 18, '57, p. 17*), they say they've been able to improve the stress-strain properties and abrasion resistance of conventional rubber stocks; improve the dimensional stability of uncured butyl; and produce gasket, mechanical rubber and blown sponge stocks that appear to offer "significant advantages over those obtained with conventional compounds used today."

The picture is not all bright, of course. In some cases, the polyethylene additions seem to make the rubber somewhat more difficult to process and more likely to crack. But Phillips emphasizes that research is still in its early stages and believes these difficulties can be overcome.

Average price of transistors will drop below a dollar . . .

. . . by 1965 (average price today: $3.50), predicts J. A. Morton of Bell Labs, and unit sales will climb above 800 million (current annual rate: about 30 million). Those are big changes for a 7-year period—but no more surprising than those even in the past four. (Unit sales were barely 1 million in 1954; and average price was over $5.)

On the technical side, Morton predicts that the 700-F semiconductor is well in sight, as are new variable capacitance amplifiers operating at 6000 mcps, new voltage-regulators, and switching devices for 100 to 1000-mcps computing speeds.

Photosensitive plastic sheet . . .

. . . that can be "water-etched" to produce printing plates or dials requiring relief markings (*PE—Nov. 18, '57, p. 8*) takes another big step toward commercial introduction. DuPont is planning a full-scale demonstration of its process to printing industry representatives late next month, will make technical data available at that time.

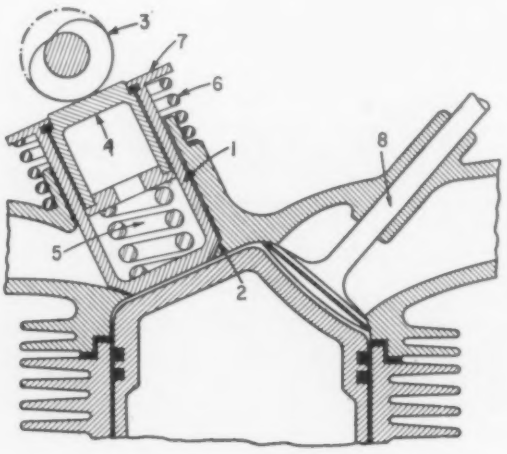
As originally announced, the printing plates are made by exposing a photosensitized plastic sheet to a photographic negative in the usual way, except that an ultraviolet light source is used. This light hardens the exposed areas, while the developing process softens the unexposed areas so that they can be washed away by an alkaline water solution.

Though field evaluation of the plates is already underway, and more tests are planned, there has been no change as yet in the commercial availability date. It is still quoted as "late 1960."

Novel exhaust valve . . .

. . . designed in Austria, has cup-shaped body that opens to the outside, is said to permit much faster cooling, and reduce chance of misfiring.

According to the designer, F. Hell, Mollardgasse 20, Vienna VI, the fact that the valve body has a cross-section 15 to 25 times that of a standard valve stem, makes for excellent heat dissipation while providing a positive seal. The diagram at right compares the two types, and indicates major parts of the new valve.—ARG



Cup-shaped valve (1) is pressed against a seat (2) which widens conically into the exhaust pipe. Cam (3), acting on tappet (4) and spring (5) holds valve down. Coil spring (6), acting on collar (7) opens it. Standard intake valve (8) is drawn at right for comparison.

Prototypes and Other Production Delays Blasted by Air Force Materiel Chief

Interviewed by Product Engineering, Lt. Gen. Irvine also hits poor liaison among contractors and lead-times lasting 20 years, calls for end to "hurry-and-fix-it" philosophy.

WASHINGTON—Developing a rocket engine with a million-lb thrust, designing a plane that can speed at Mach 3 and 4, perfecting a nuclear engine for aircraft . . . these are difficult problems. But there is a problem as great or even greater, says Lt. Gen. C. T. Irvine, Deputy Chief of Staff for Materiel, US Air Force. It's the need to get such new and improved weapons into production quickly.

In an exclusive interview given PRODUCT ENGINEERING, the technology-minded general pulled no punches. He hit at "hurry-up-and-fix-it people" who dally too long with prototypes, at poor liaison between prime contractor and subcontractors, at administrative delays that can expand lead time into over 20 years.

Explaining his interest in the tempo of production, Gen. Irvine pointed out: "With our present capabilities we are entitled to expect as great a rate of progress in the next five years as we have had in the past 50. We have crossed the bridge from subsonic to supersonic speeds and have learned much in the process. We have made arithmetical progress in the past and expect to make geometrical progress in the future."

Here are points covered:

Prototypes

QUESTION: "Are there any attitudes or practices military suppliers should alter to make the rapid changes required in the future?"

ANSWER: "The aircraft industry will have to get out of the cut-and-try prototype habit, without engineering the tools and complete system to go with prototype models of a potential production system. Prototypes are an indication that engineering design has not been completed in detail—senior design people agree on this. Engineering today is too often conducted by the cut-and-try method. The B-52X and the B-52Y prototypes cost $100 million but we got a lot of production and tool engineering for it.

"We were in a position to kick off fast on the production program as a result of the amount of effort we put into these early models. In 1930 a good designer named Stinson made planes with tubing, hack saw and welding torch. If he didn't like something on the plane, as it was being built, he cut it out. Some segments of the aircraft industry have made little progress since then in the philosophy of how to build. We have a host of hurry-up-and-fix-it people designing today.

"The time required to build prototypes is even more serious than the cost unless the complete paper job to lead into production is accomplished at the same time that the first bits and pieces of metal are proving the design philosophy. With supersonic wind tunnels and electronic computers available today engineers should explore possibilities more thoroughly, coming closer to the final design of the product than is now the case and build the first item on production tooling. The Air Force has also had some very expensive experiences with forced production on paper design. We gained little if any time and we found that we had too much work force too soon. We have learned the paper design of a complete system and production tooling is subject to extensive changes before usable operating hardware can result. In addition, the investment required to sustain this type program normally forces us to eliminate all competition at the 'brochure sales' stage, an unhealthy situation.

"These complicated models can't be scratched out of metal haphazardly and the step from paper dreams to metallic reality is a big one. We like to give ourselves time in the initial development schedule to grind in the lesson we learned from the first lot of metal through the shop, and to the second lot so we can get sound results fast. The complexity associated with new weapons and overlooking design has created reliability problems of first magnitude. Combat weapons that work only part way have little value."

His Other Attitudes

"We have a problem, too," Gen. Irvine said, "With the industrialist who gets a production line going and forgets about it—it is easier to let it run itself. As soon as a design team fin-

"We have made arithmetical progress . . .

. . . in the past and expect to make . . .

. . . geometrical progress in the future"

ishes a job, company management should put it to work designing the next model. The companies that plow a large portion of their profits into R & D and new equipment are the ones that survive.

"Certain traditions are a handicap too. One problem we face is the fixed-price contract. Industry generally prefers cost plus fixed fee. But Congress and the Executive branch think we should do more business at fixed price because such contracts contain incentives for companies to do an outstanding job. When a company does a superlative job it should be allowed to earn profits approaching the legal limit of around 15%.

"Those who do inferior jobs should get no profits.

"There is much variation of management performance in holding costs down. For instance, the scrap rate on machine shop work varies widely. I've seen it run as high as 50% and low as ¼ of 1%. Normally it runs around 3%.

The Subcontractor

"Very important to good management in the aircraft industry–and where many industries have failed–is effective handling of subcontractors. About half the components of an aircraft, and somewhat more on a missile, are manufactured by subcontractors. The prime contractor essentially runs an assembly plant. With its suppliers spread across the country, the prime contractor has a problem in scheduling and coordinating work. Maintaining quality control is also difficult. The man who must deal with subcontractors handles a crucial job; yet I once knew a company whose president didn't know the name of this man."

Standardization

QUESTION: "How much standardization in missiles and aircraft is possible in a period of rapid technical change?

ANSWER: "Standardization is possible to some degree, and we are trying for more–particularly in missile support systems. In the Air Force we can standardize an end item for no longer than two or three years. Some components are good for five years. However, we run into specialized needs in such items as fuel, test apparatus, and handling equipment. While every effort is made to standardize the smaller items, the performance gains we demand run counter to interchange of larger components between weapons systems. The higher performance we obtain with our weapons, the more the total system becomes tailored.

While trying to tailor the outside of a black box for restricted flight into space – which will vary from weapon to weapon–we are also trying to get common insides for black boxes."

Lead Time Too Long

QUESTION: "What is the best we can expect in cutting product lead time?

ANSWER: "I wish we could get it down to 12 months. But I doubt we will get it much below 18 for any design that is complex. Actually, lead time breaks down into three phases: design, manufacturing, and administration. Design takes from three to seven years, manufacturing from 10 to 17 months for a plane and 14 months for a missile.

"We looked informally for about five years at the proposals for the F-108 (a North American Aviation Corp. contracted, long-range fighter in the Mach 3 to 4 range). The delay was because the companies came up each time with more of the same thing so we marked time with the F-101 and F-102 in the Mach 2 range. That F-108 required technical advances in propulsion system and materials for the fueslage, and new wing-design concepts. Finally, a stainless honeycomb gave us a material capable of resisting sonic vibrations. And the long wing allowing good lift-drag ratios at subsonic flight was modified to an almost diamond contour for Mach 3 flight.

"Administrative time can vary from 1 week to 20 years. Initially, it depends on matching new designs with military needs and available funds. After selection of a system for development and production, administrative time relates directly to priority of the system and program control by the contractor and Air Force administrative system. Unfortunately, multiplying administrative organizations encourage too many people to do someone else's business."

Automation–Or Else

QUESTION: "What advances in manufacturing processes and technical know how are required for companies who expect a share of tomorrow's military market?

ANSWER: "Anybody in the field who does not have an almost completely automatic production line in three years will find himself out of business. In vacuum tubes of a few years ago, variations were enormous because of extensive hand labor; the variations impaired quality of military electronic systems. With automatic manufacturing methods, tube life has been stretched to 1000 operational hours.

"There is, of course, a lag between development of a material or process and its application. For example, precipitation hardening stainless is not fully utilized. It's a rough rule of thumb that if you design one pound out of the structural weight you can cut five pounds out of total plane weight, and substantially increase capability. The advantages of a high strength material are often well worth the high price.

"Small companies, incidentally, have always reacted more quickly to change than the large ones. Many recent innovations have originated with small companies–such as low-draft forgings, and the investment casting processes."

Which Labs?

QUESTION: "What are the government laboratories doing to help improve design and production?

ANSWER: "In contrast with some of the other Services, we've not made much use of Government labs. Best way to make progress is a marriage of military people, who know what is needed, with industry, which has specialized technical knowledge. Nobody ever did anything by himself. Navy says it developed the Sidewinder at China Lake more economically than it could have been done in industry. Still, much basic work was done by industry and Navy drew upon this source. Navy did work on infrared but did not develop the seeker device (See PE–June 30, '58 p. 14) for a new use of infrared. The ABMA (Army Ballistics Missile Agency, Huntsville, Ala.) collaborated with Ford Instrument on the instrumentation and guidance with Libbey-Owens Ford on materials, and purchased engines from North American under Air Force contract.

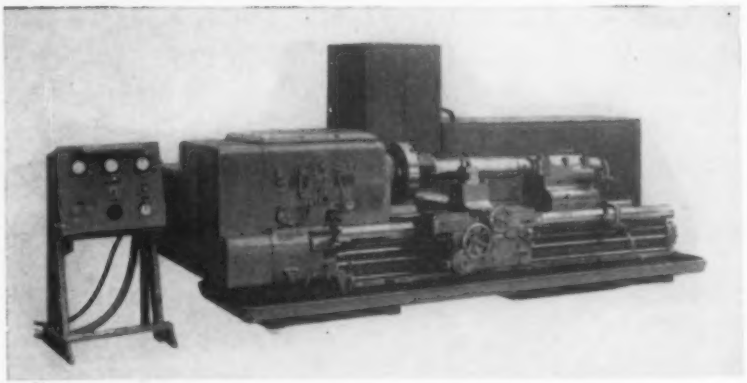
New Cutting Tools Accelerate Machine Tool R&D

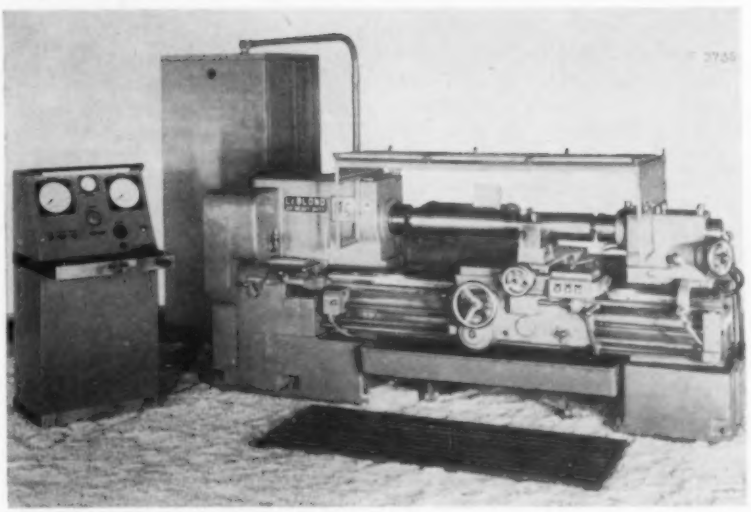
DETROIT—Debut of new cutting tool materials that require more power and rigidity is today a major reason for redesigning metal-cutting machine tools.

Often, the machines make their first appearance for the purpose of testing the new tools; then, they become the basis for design of a new line of machine tools that generally supplement and occasionally replace the old ones.

Redesigning of machine tools every seven to 10 years is no longer adequate; soon R & D leading to machine tool redesign will be a continuous function of the machine tool industry. For example, three years ago the R. K. LeBlond Machine Tool Co. produced an advanced lathe design to take advantage of the new tungsten and tantalum carbides. Ceramic (cemented oxide) tools (*PE*—Apr. 28, p. 36) led LeBlond to produce a special lathe on which these new cutting tools could be tested and demonstrated. Now, Ford Motor Co.'s research department has come up with another tool material, cemented titanium carbide, which may start the cycle all over again.

A comparison of two lathes produced by LeBlond indicates the direction these machine tools are heading, and the type of problems that have to be solved. Basic design for the first of the two—designed for carbide tools—was changed little except for rigidity. Tungsten carbide called for speeds between 200 and 600 sfpi; tantalum carbide, 500 to 1000 sfpm. Spindle speeds from 42 to 700 rpm were provided by a 2:1 variable speed motor and four change gears. A 125-hp drive motor was required; feed range was from 0.002 in. to 0.125 in.





Progress of lathe design . . .
Top, special LeBlond 32-in. roughing lathe designed three years ago for carbide tools. Spindle is geared to motor and speeds are between 42 and 700 rpm (doubled with optional belt drive). Maximum surface speed is about 1000 fpm. New lathe designed for ceramic tools (photo below) has direct-connected motor which eliminates gears and rotates part at speeds between 250 and 5000 rpm, giving face speeds up to 18,000 fpm. Chuck is discarded to eliminate one source of vibration. Ceramic tools produce a finish that compares favorably with rough grinding.

DIRECT-DRIVE SPINDLE

For ceramic tools, minimum efficient speed is 900 sfm. In tests at GE's Metallurgical Products Div., speeds of 18,000 sfpm have been reached with no adverse effect on tool life. Surface speeds of this magnitude couldn't be achieved by change gears; a 150-hp variable speed dc motor is directly coupled to the spindle to give an infinite range from 250 to 5000 rpm.

Because of the high speeds, both front and rear spindle bearings are of large size. Internal bearing clearances are eliminated by positioning the inner bearing race on a taper on the spindle. Bearing oil temperature is thermostatically controlled.

Feed drive is through two reductions from the spindle. The first is a 1:2 ratio from the spindle to an intermediate shaft; the second, a 3:4 reduction to the gear stud. Both drives are by timing belt. A gear reduction, with a steel gear running with a nylon gear, completes the train.

Because of the high rotating speeds, imbalance of the piece being machined can set up excessive vibration. Therefore, parts must be roughed out before setting them up on the finishing lathe, and the ends must be cut perfectly square.

Conventional chucks can't hold the part; instead, the part is held by two pins seated in the squared end of the part. These two pins act as a lathe dog. Because the pins allow a slight axial movement of the part, LeBlond expects to replace the pin drive with an Erikson collet chuck.

Ceramic tools are especially sensitive to vibration. Vibration may also be produced by the machine itself or by the motor-generator unit feeding the dc motor.

Develop Powerful Electromagnet at Univ. of California

BERKELEY, CALIF.—An electromagnet in operation at the University of California here produces a flux density of 96,700 gauss, uniform to 0.1% in a field of 30 cu in. Magnet casing is 15 in. dia and 26 in. long; core is 4 in. dia. Conductors are ¼ x ¾-in. copper rods spaced to permit flow of coolant —kerosene is pumped at rate of 2200 gal per min. Power dissipation is approximately 10,000 hp.

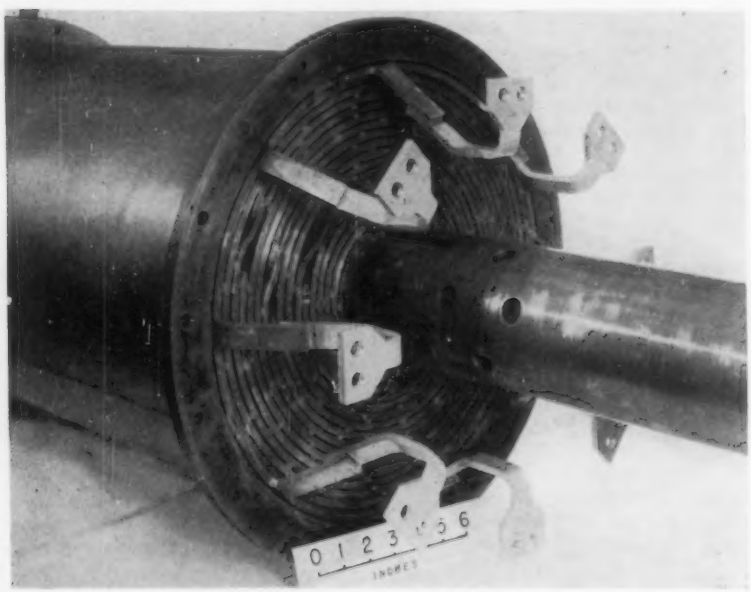
The new magnet has been designed to perform previously impossible experiments on the properties of matter in its "degenerate" state, approaching the infinitely cold. A university spokesman predicted the machine will make it possible to approach absolute zero in cooling specimens.

However, achievement of low temperatures with the magnet is secondary to the development of low temperatures. Two more magnets are planned for use in entropy measurements, solid state physics, nuclear alignment of radio elements, temperature scale and thermometry (new thermometers will have to be invented to make measurements), heat capacity, electrical and thermal conductivity measurements, magnetic measurements, thermodynamic relationships of magnetic data, and spectroscopic observations at low temperature.

New Ceramic Resists Chem, Thermal Shock

BONN—A new dense ceramic called "Temperit" that has exceedingly low heat-expansion coefficient has been developed by Steinzeugawarenfabrik, of Mannheim. It is an aluminum silicate, is resistant to chemical and thermal shocks—the latter up to 1830 F max. Also has bending strength under impact of between 8500 and 11,350 psi. The coefficient of heat expansion is 0.6 x 10^{-6} in./in./F over a range of 68 to 1112 F.

This compares with HT-2, a modified aluminum-silicate (*PE—Sept. 30, '57, p. 70*), which has a coefficient of expansion of 1.0 x 10^{-6} in./in./F. Development work presently in progress is aimed at increasing tensile strength to between 14,200 and 17,000 psi.



World's most powerful magnet . . .
is their description of this new electromagnet designed by the new Low Temperature Laboratory at the Univ. of California. Note the terminals in place and the annular rings in the magnet winding through which kerosene is pumped for cooling during operation. With 10,000 hp input, the magnet produces a field of about 100,000 gauss.

COMING EVENTS

AUGUST

6-8 . . . . American Institute of Electrical Engineers, Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers, Hotel Statler, Los Angeles.

11-14 . . . . Society of Automotive Engineers, National West Coast Meeting, The Ambassador, Los Angeles, Calif.

13-15 . . . . American Institute of Electrical Engineers, Institute of Radio Engineers, National Bureau of Standards, Conference on Electronic Standards and Measurements, NBS Boulder Laboratories, Boulder, Colo.

18-21 . . . . American Society of Mechanical Engineers, American Institute of Chemical Engineers, Joint Heat Transfer Conference, Northwestern, Evanston, Ill. .

19-22 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Hotel Senator, Sacramento, Calif.

19-22 . . . . Western Electronic Show and Convention, Pan Pacific Auditorium, Los Angeles.

SEPTEMBER

1-7 . . . . International Association for Analog Computations, Second International Conference for Analog Computations, Strasbourg, France.

4-5 . . . . American Society of Mechanical Engineers, International Conference on Air Pollution, Hotel Statler, New York.

8-11 . . . Society of Automotive Engineers, National Farm, Construction, and Industrial Machinery Meeting, Production Forum and Display, Milwaukee Auditorium, Milwaukee, Wisc.

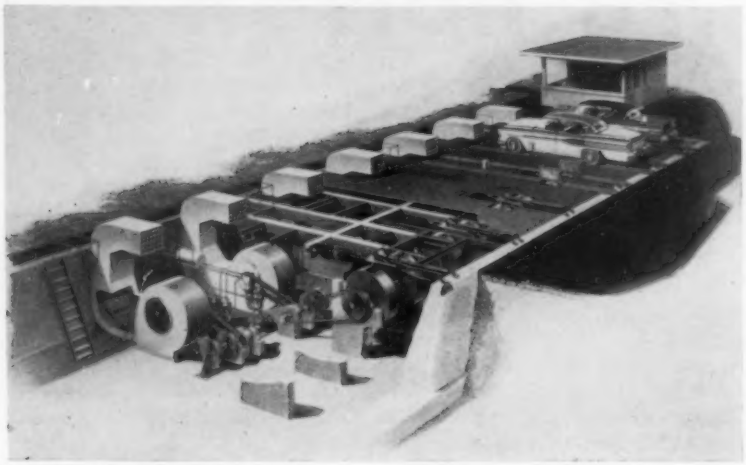
12-13 . . . . Society of Plastics Engineers, Regional Technical Conference, Plastics for the Automotive Industry, St. Clair River Inn & Country Club, St. Clair, Mich.

15-19 . . . . Instrument Society of America, 13th Annual Instrument-Automation Conference and Exhibit, Convention Hall, Philadelphia.

23-26 . . . . Association of Iron and Steel Engineers, 1958 Iron and Steel Exposition and Convention, Cleveland Auditorium.

24-25 . . . . Institute of Radio Engineers, Seventh Annual Symposium on Industrial Electronics. Rackham Memorial Auditorium, Detroit, Mich.

24-26 . . . . Porcelain Metal Institute, Annual Meeting, The Greenbrier, White Sulphur Springs, West Virginia.



Testing driver-less cars . . .
On Esso Research and Engineering Co.'s new automated test stand, driver-less cars are operated from control house with accelerating and braking cycles controlled by magnetic tape to duplicate actual driving conditions. New fuels and lubricants can thus be tested under more closely controlled conditions than on actual road tests.

Automated Test Stand Replaces On-the-road Driving

LINDEN, N. J.—An automated test stand accommodating up to eight unmanned automobiles that can be "driven" simultaneously by one man stationed in a control house is in operation at the Esso Research Center here. The test stand, designed to evaluate experimental motor fuels and lubricants, was developed by three Esso research engineers.

Magnetic tape recordings, made during on-the-road runs, control the acceleration and braking cycle of the test cars to duplicate exactly the way a motorist would start, accelerate, slow down and stop his car during normal driving. The installation can also be set for fast, uninterrupted turnpike driving, or for a combination of open road and city driving.

First road test to be replaced by the new development is Esso's daily "milk run," a 3½-hr, 101-mile drive through metropolitan New Jersey traffic.

To absorb engine power the rear wheels ride on and rotate steel drums, which drive "inertia disks" and large fans. The inertia disks absorb the power an automobile would normally use to accelerate its weight along a conventional road. They are adjustable and can be set to correspond with the road weight of any car—including a driver.

Fans absorb the power a car would ordinarily expend in overcoming wind resistance on the open road, and also cool the engines.

The test stand provides more accurate test information than is obtainable from conventional road runs because different fuels and lubricants can now be compared under unvarying conditions. Vapor lock and transmission tests can be run at speeds up to 100 mph. Also, it eliminates the hazards of test driving on congested roads and highways.

Airlift May Compete With Surface Transport

SANTA MONICA, CALIF. — Air-lift transportation from the US to overseas is now competitive with surface transportation, according to Donald W. Douglas, Jr., president of Douglas Aircraft Co. He said the Douglas C-133 Cargomaster makes this possible.

Powered by four Pratt & Whitney T34 turboprop engines, the C-133 has a cruise speed of 323 mph, can transport a max payload of 90,000 lb. In addition, a special loading conveyor and tiedown system facilitate loading and unloading of cargo. In a demonstration of the latter facilities, six men loaded and secured 33½ cargo tons in 40 min.

Dimensions of the C-133A (and an improved version, the C-133B) include: wing span, 179 ft., 8 in.; over-all length, 157 ft.; over-all height, 48 ft. The C-133-B can transport more than 25 cargo tons 3,500 nautical miles.

According to Douglas, the craft can transport any missile of US design along with necessary components and supporting equipment 20 to 30 times faster than surface transportation. A recent study showed that airlifting a missile with the C-133 cost $9,200 and required only seven hours, while surface transporting the same missile cost $14,000 and took nine days.

Bits and Pieces

A new program for aeronautical engineers at the Univ. of Detroit will emphasize a fundamental core of courses in the humanities, science, mathematics and engineering followed by specialized courses in aerodynamics, aeronautical structure and propulsion systems. The student will get fewer design and application type problems in the school curriculum, but will pick up the practical applications in off-campus supervised industry training.

A used analog computer can now be traded in for credit on a new model. The trade-in service instituted by Mid-Century Instrumatic Corp. will allow customers as much as 50% credit toward the price of the new machine. Mid-Century expects to lease or sell the second-hand computers to industries such as steel, pulp and paper, chemicals where computers have not yet been widely used or evaluated and where the cost of a new computer might seem prohibitive for a speculative venture.

A European Atomic College to train an adequate supply of scientists and engineers for projects sponsored within the European Common Market will probably be located in Milan, provided the city is not chosen for headquarters of the Common Market. Euratom's nuclear research center with a budget of $215 million may also be set up in Italy. Participating countries are Belgium, Holland, France, Luxemburg, Italy and Germany.

READER TO EDITOR

Helicopters or Ornithopters?

To the Editor:

The June 9 issue has on its cover a varied group of aircraft above the word "Ornithopters" and shows, I believe, only one ornithopter as depicted in Leonardo Da Vinci's sketch. The various others are helicopters and other types of aircraft fitted in every case with non-flapping wings. The "Ornithopters" heading I believe to be in error; only one is in evidence.

—HERBERT R. POLLEYS
New Haven 15, Conn.

• *You are completely correct. In this case it seemed desirable to have a single-word title, so we applied it to Da Vinci's design. The others are more properly rotating-wing and propeller-driven aircraft of various types, and are probably more directly related to the maple seed than they are to the bird, if we trace them back to the natural source of the idea.—Ed.*

Work Your Plan

To the Editor:

In reference to the editorial, "The Case-Study Fallacy," June 23, p. 67, the Boy Scouts of America have had a slogan for many years which his appeared in training literature for Boy Scout leaders: "Plan your work, and work your plan."

In Scouting as well as in business, "no amount of planning can be substituted for a little horse sense when the going gets rough!"

—E. W. STECHER
Oak Park, Ill.

Russian Education —Undesirable

To the Editor:

It irritates me that education in the US is lately being evaluated relative to the educational system in the USSR. This gives the impression that our education was adequate until Sputnik darkened our skies. It further gives the impression, not only that Sputnik proved that our production of professional people lags behind in quantity and quality now, but that Russia's educational system is the only desirable system, and in many respects to be copied. As one who received his professional training in the Netherlands I take the liberty to state that Russia's education is regarded in Western Europe to be second-rate and undesirable. The reasons for this low rating are based partly on the comparison of subject matter, but mostly on the lack of general "education," which goes with the training of the professional man in Russia.

The Western European high schools and notably those in the Netherlands offer a training which gives more mathematics, more physics, more chemistry, but on top of that, more "education" than any high school in Russia. Anyone who enters the university should already have mastery of three foreign languages (French, German and English) in writing and speech and have a thorough knowledge of the history, literature and culture of these countries. In short, on entering the university the student is "educated." Training in his profession then proceeds on subjects concerning his profession only. Mathematics, physics and chemistry are started on a level where US universities usually end. Many textbooks are in foreign languages, many courses are given in foreign languages. Often these are required to be written in either French, English or German.

The cultural development is secured in the atmosphere of "free student life." Result is a professional man highly qualified in his profession, and at the same time culturally developed to the point where he could easily shine in our State Department where the painful results of our education are only too glaringly obvious.

By contrast, Russia's education is as limited and blindfolded as ours. It is just better, that is, more thorough —but still limited.

The real danger is from the Western European professional man who has learned that science is a basic function in life; with this science he has been capable of creating a livelihood on an overpopulated piece of real estate where we would have starved to death. More important, the Western European has also learned that science itself is not an end, but a means to an end. He regards the basic philosophy behind this science and the morals of living as the only important things in life. Where European industry never really presented an economic threat to us, because of the multitude of smaller nations, it will before long, with creation of the European Common Market making full use of their superior knowledge of science and the world.

If we decide that our education needs revision, and it certainly does, we should do well to study the systems of Holland, Belgium, Switzerland and Western Germany.

—J. J. LOWEY-BALL
Union Carbide International Co.

Brilliant but Lazy

To the Editor:

The personnel policy of Heurtey (*PE*—June 16, p. 2) is nothing more than the basis for selection of students for officer training in the old Prussian army. This has been generally used in military circles ever since (but purposely not publicized for fear eager beavers would conceal their true natures until they reach high enough rank to cause real difficulty).

—FRANK ROKETT
Staff Editor
McGraw-Hill Encyclopedia of Science and Technology

• *When our freshman algebra class at Purdue, 33 years ago, neared the end of the semester, our instructor asked casually how many of the students were up to date on solutions to 700 homework problems. I sleepily shoved my hand up—and as hastily pulled it down, because it was a solo performance. Said he: "That confirms my opinion that you're one of the laziest men I ever met. Only lazy people do things on time; they know that catching up is more work."*

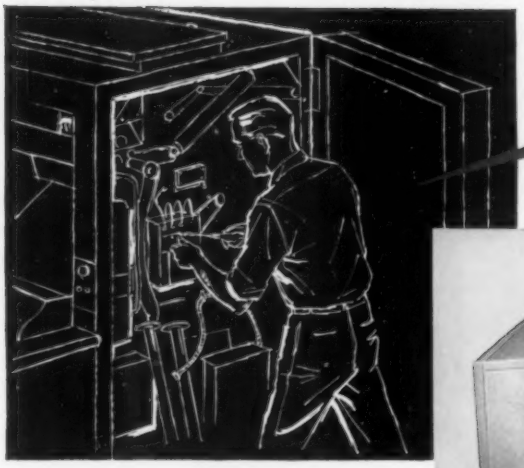
I've never forgotten his remark. And it's as true as the day is long. But the French company insists that management candidates must be brilliant too. That's a different story. —*EJT.*

Personal Prestige at Stake

To the Editor:

Since a new yearly model (June 2, p. 30) has more to do with personal prestige than function or design, I don't know how else we may keep within our social strata if we couldn't buy the '59 models.

—NAME WITHHELD



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creative designing calls for an open mind

Leonardo Da Vinci's design for a pump using the Archimedian screw principle

Model courtesy of IBM

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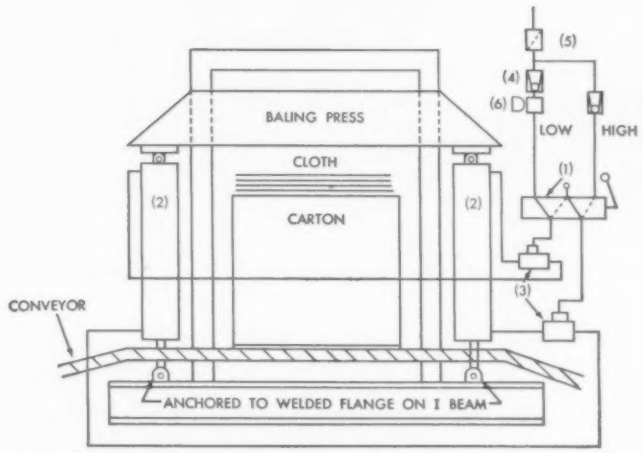
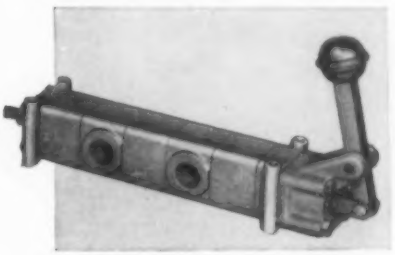


Devices: (1) PD4-42-0001 PILOTAIR® Valve (2) "A" Cylinder (3) Quick Release Valve (4) Reducing Valve (5) Filter (6) Lubricator



"D" PILOTAIR® VALVE

The Westinghouse PD4-42-0001 PILOTAIR® Valve is the key to this entire pneumatic control system. "D" PILOTAIR® Valves are two-, three-, or four-way directional valves, with lever, cam, solenoid, pneumatic, pedal, and treadle operation. They have two and three positions, with port sizes of ¼" and ½" ips. They provide a choice of over 30,000 valve operator positions. Maximum operating pressure: 250 psi.

The diagram shows a baling press at the Arista Mills Company in Winston-Salem, North Carolina, makers of blue chambray cloth. The press was recently converted from heavy gear operation to pneumatic control. The pneumatic control system was designed by the Livingston & Haven Company, of Charleston, South Carolina. Westinghouse Air Circuitry has enabled Arista Mills to put 28% more cloth in each carton. Since labor costs per package are about the same as with their previous method, they are realizing an approximate 28% saving in labor costs. The heavier, more fully packed cartons also have cut handling costs, cut carton costs, and made available more critical warehouse space.

What is air circuitry?

Air Circuitry is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise Air Circuitry is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

FREE BOOKLET

For more details, send for the free booklet, **Basic Pneumatic Control.** This informative 28-page brochure pictures and explains the advantages of Westinghouse Air Circuitry. We'll also send you a booklet of Datair Sheets containing diagrams and descriptions of recent Westinghouse Air Circuitry installations.

Westinghouse Air Brake Company
Industrial Products Division, Dept. PE-88
Wilmerding, Pennsylvania

NAME .....

TITLE .....

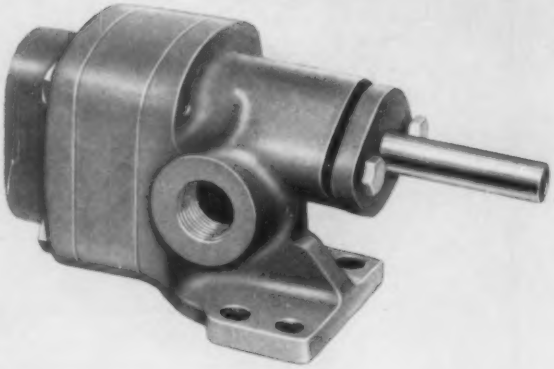
FIRM .....

ADDRESS .....

CITY ..... STATE .....

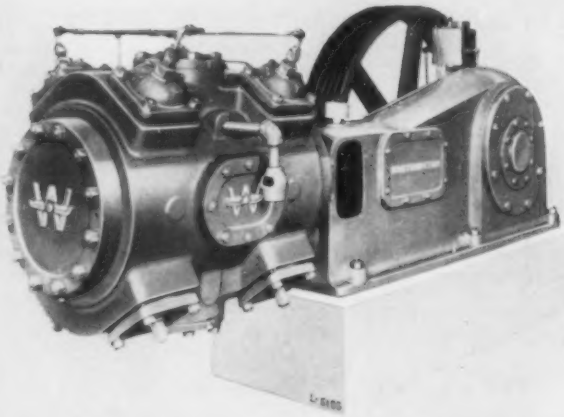
Westinghouse Air Brake
COMPANY
Industrial Products Division
WILMERDING PENNSYLVANIA

Monobloc Rotary Pump



Rotary Pump

Monobloc Centrifugal Pump



Water-cooled Compressor

On any pump or compressor you choose, only Worthington gives you these

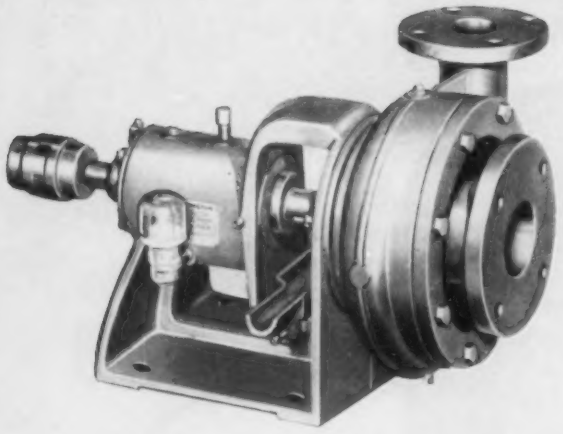
EXCLUSIVE

Feather Valve Lightest, fastest-acting compressor valve available. Works with no impact, is all but indestructible, and has an amazing record of long life with negligible maintenance costs.

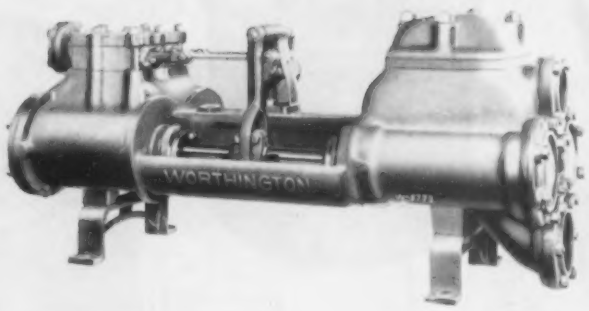
70,480 Combinations Completely standard and interchangeable components let you save up to 50% on spare parts inventory, permit you to design and build over 70 thousand "special" pumps using but 6 SESC pumps.

Monobloc Rotary Pump Eliminate alignment problems, simplify layouts by choosing up to 28 different ways to hook up pump piping. Saves you time, materials, is less expensive than separate pump, motor and baseplate.

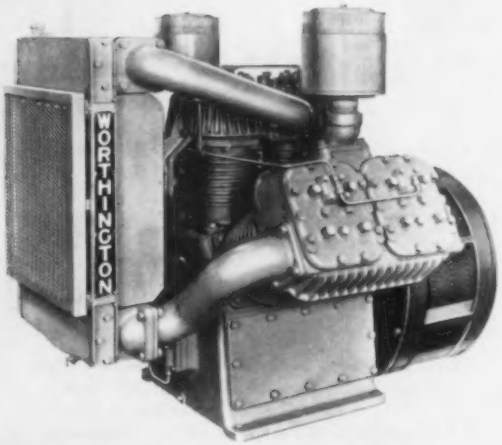
CIRCLE 116 READER SERVICE CARD



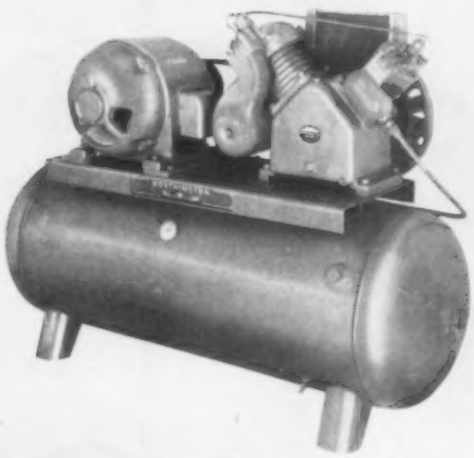
Chemical Centrifugal Pump



Steam Pump



Radial Air-cooled Compressor



Balanced Angle Air-cooled Compressor

DESIGN ADVANTAGES

Designing and manufacturing outstanding products has been a success story typical of Worthington for 118 years. Foremost examples of this leadership and engineering skill are the exclusive design advantages of Worthington pumps and compressors. Three of the most important are illustrated at left: Feather Valves*, Monobloc Rotary pumps, and the unmatched flexibility achieved through standardization of the SESC (Standard End Suction Centrifugal) line.

Worthite*, Worthington's *super* stainless steel, has set new corrosion resistance standards for chemical pumps. Worthington air-cooled or water-cooled compressors include carefully balanced operating parts, low piston speeds, and liberal cooling surfaces on cylinders and intercoolers or aftercoolers. Increased performance and accessibility of portable and balanced angle compressors and the money-saving benefits of easy installation and low maintenance of the entire pump and compressor line lend further testimony to Worthington engineering competence. But whatever your application, your design problem, Worthington can help you.

Your nearby Worthington representative stands ready to explain the many advantages of one *complete* Worthington pump and compressor line to you. For more information on how to improve your product's performance or reduce engineering design and expense, contact him now. Or write for bulletin, Worthington Corporation, Section 104-7, Harrison, N.J. In Canada, Worthington, Ltd., Brantford, Ontario.

WORTHINGTON

*A high-nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U.S. Pat. Off.

CIRCLE 117 READER SERVICE CARD

New easier way

... to use stainless steel lock wire!

Note how the lock wire, uncoiling from the inside, is dispensed as needed from a hole in the top of this compact 1-pound package. No wild uncoiling! Moreover, the wire is better protected, handles easier and faster, with less waste, and with greater safety!

Here is a new National-Standard packaging development that is a natural for most safety lock wire uses in equipment manufacture, assembly and servicing.

For production operation requiring larger capacities, National-Standard offers lock wire on practical 5 and 10-pound disposable spools that may be spindle-mounted.

Check with National-Standard on the spooling of your choice and on stainless steel lock wire in any diameter from 0.020 to 0.067 and to government specifications: QQ-W-423, AN-W-24, MIL-W-6713 or AMS-5685-C.

NATIONAL NS STANDARD

DIVISIONS: **NATIONAL-STANDARD**, Niles, Mich.; *fine wire, stainless, music spring and plated wires*
WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires high and low carbon specialties* • **REYNOLDS WIRE**, Dixon, Ill.; *industrial wire cloth*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • **ATHENIA STEEL**, Clifton, N. J.; *flat, high carbon spring steels*

CIRCLE 118 READER SERVICE CARD

Modernize Now for Growth and Profits

A Special Report from McGraw-Hill to America's Business Executives

THE EDITORS of all McGraw-Hill publications are now devoting their full energies to documenting what needs to be done *now* to assure success in the 1960s for:

1. Individual companies in the key areas of business and industry these publications serve
2. The business community as a whole
3. The nation—in its fateful economic competition with the Soviet Union. The U. S. State Department has characterized this economic challenge as "the most dangerous of all" confronting us.

These editorial features will concentrate on what can be done *now* by modernization and improvement of plant and equipment to raise productivity and insure profitable growth ahead. They will appear early this fall in our 34 business and technical magazines, to assist industry in planning for the future.

We believe this special editorial undertaking by all of our publications, working as a team, will prove another landmark in our continuing efforts to speed America on the road to full economic recovery and sustained economic growth.

Donald C. McGraw

PRESIDENT

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Selecting the right grade of nuts

"Workhorse" among nuts is the standard "FINISHED" series. It gives good seating area; sufficient height to sustain high thread tension; enough wall thickness to control elastic nut dilation under load.

"HEAVY" nuts are wider than "Finished" nuts in *all* sizes by only ⅛" across flats. Thus, their value diminishes as size increases. Most effective in ½" to 1½" range, they satisfy applications involving excessive clearance holes, unusual loads, and certain boiler codes.

MATERIALS? The regular carbon nut steel (non heat treated). It makes nuts strong enough to pull bolts beyond yield point, lets threads distribute load to avoid stripping.

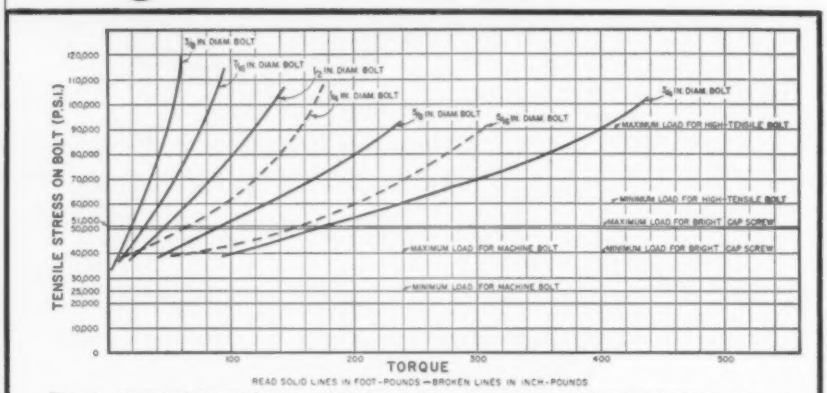
NUTS WITH "SPECIAL" FUNCTION

JAM NUTS are made for position locking. Use of two together forms a superior and economical locking device. When used to lock a regular nut, jam nut should be adjacent to work surface. Otherwise, the jam nut takes the load – a job it wasn't designed for.

Use a 2H NUT where high temperatures call for stability.

HIGH NUTS are used for shackle, U and tractor pad bolts. They're furnished only in fine threads, therefore, and hardened. More to be recommended are *coarse thread* finished nuts.

Tightening up fasteners tightens down on costs



These curves suggest torques for proper tightening of three grades of standard fasteners. Tightening to the upper limits delivers more of the holding power paid for, and assures stronger joints. Dropping below minimum values wastes fastener strength, invites loosening and failures. These curves are reproduced in RB&W Booklet DC-1.

It pays to go the limit in tightening bolts. Not only is it more economical, but safer too. For strength of a rigid connection depends on *residual tension* rather than on how strong the bolts are. Applying this fact can help avoid cost penalty.

EXAMPLE:

Blueprint specifies alloy bolts with strength of 145,000 psi. But assembly specification calls for tightening to what has been found an adequate pre-loading . . . only 30,000 psi. This wastes the fastener's capacity. It provides no more joint-strength than supplied by a *far more economical* RB&W bright cap screw tightened to same pre-load. It would be better to switch to the lower grade, or reduce size of the premium grade fastener.

REDUCING SIZE ALSO SAVES

A fastener's holding power is the same as its pre-load, or residual tension. So long as it permits tightening to the required pre-loading, the bolt can be small as possible.

EXAMPLE:

Design requires fasteners with safe load capacity of 20,000 lbs. Bright cap screws of ¾" size will do it; but so will ⅝" RB&W High Strength Bolts – *at less cost*. Actually, for the same holding power as in $1.00 worth of high tensile fasteners, $1.50 worth of bright cap screws are required.

PRODUCTION BENEFITS

Along with direct savings, smaller bolts mean smaller holes to drill or tap. Smaller holes often allow reduction in size of fastened members.

Talk to an RB&W fastener expert at the design stage of your product. He can help you cut costs without cutting joint strength.

Meanwhile, send for helpful booklet DC-1. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

PERSPECTIVES

in design and development . . .

Universities: Aids to Industry's Research

Some months back, Dr. Lee DuBridge, president of California Institute of Technology said, in urging higher salaries for college professors, that colleges and universities throughout the country are being subsidized by their faculty members. In the nation as a whole, these educators forego a billion dollars a year in salary because they love to live in a university atmosphere. He added that the universities are courting disaster if this is allowed to continue.

Recently, at the annual meeting of the American Society of Engineering Education, engineer-college faculty members got another boost. Robert H. Ramsey, of Pennsylvania State University, in his report on an ASEE survey of research activities and resources at 108 engineering schools, counted almost 6,500 members of engineering faculties active in research during the 12-month period ending June 1957. "Their part-time work in research," Ramsey said, "supplementing their teaching duties, represented the equivalent of 1,668 full-time workers. But, during this same 12-month period, this group could have spent additional time on research to equal 549 full-time workers—if funds had been available."

Ramsey felt that despite the fact that these engineering schools are well equipped to undertake basic research, financial demands force many of them to operate heavily in the area of applied research. "If engineering administrators had their way," Ramsey said, "basic research would displace nearly all of the applied research."

The ASEE survey, made with a grant from the National Science Foundation, showed that the 108 schools spent $86.4 million on engineering research during 1956-57. Breaking this figure down, it revealed $53.4 million, or 62% of the total, was spent for government-sponsored military research; $11.5 million for research under industrial contracts; $10.6 million for government-sponsored nonmilitary research; $7.1 million for self-supported research; $2.7 million for research under industrial grants; and $1.1 million from miscellaneous sources.

The report showed that between $10 million and $25 million more could be absorbed immediately in colleges and universities to bring presently available personnel up to full research potential. But, such an expansion would require new facilities—computers, high- and low-temperature labs, isotope labs and reactors—all meaning an additional investment of about $200 million. This equipment also could be used for instruction as well.

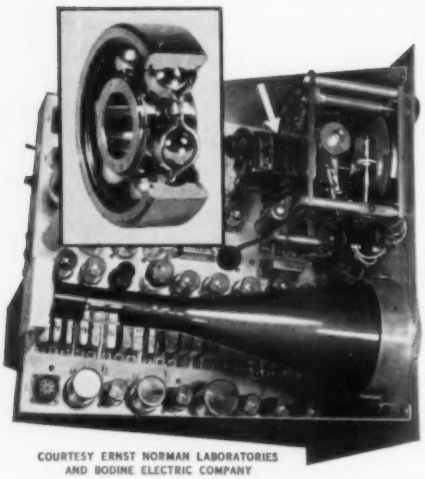
But Who's to Pay

Where would such money come from? The Engineering College Research Council figures that "substantially increased support for basic research" should come from agencies like the National Science Foundation.

Karl B. McEachron, of Case Institute of Technology, suggests another source—industry: "Industry has had to approach colleges to offer financial help for research, and it's time the schools took the initiative. While industry has contributed to fellowships, that help is not adequate. It should sponsor more fellowships, and these should include funds to cover the universities' overhead for basic research. Industry once depended on universities for research, but now industry is doing its own research, particularly that directed to specific ends, and it has paid off handsomely. To get industry re-interested in college programs, schools must find an area of research where industry can't compete. The answer is a re-emphasis on the education-research combination." —Paul Anderson

ND FACTS

HOW TO "CLOCK" A SATELLITE!



COURTESY ERNST NORMAN LABORATORIES AND BODINE ELECTRIC COMPANY

This micro-clock mechanism drives a 6-inch dial at one rev./second, giving time determinations more accurate than 0.001 second. New Departure precision ball bearings were specified for the electric motor.

Keeping track of our speedy space travelers takes highly sensitive precision instruments . . . the kind in which New Departure precision ball bearings are right at home.

At present, Frequency-Time Standard instruments selected by the Smithsonian Institution are "clocking" satellites from twelve locations around the globe. Much of this precision timing is done by a micro-clock by which time is read to the 1 milli-second.

And ultra-precise New Departure ball bearings were specified in the Bodine electric motor within this sensitive instrument—timely testimony to their low friction loss, extremely low starting torque and minimum maintenance.

If you are a manufacturer of electric motors or precision instruments, call on New Departure's engineering service for help with the latest ideas in precision ball bearings.

1908–1958 GM FORWARD FROM FIFTY

ND NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering HORIZONS

August 4, 1958

WHAT would we do with a VOICE?

One argument frequently advanced for licensing engineers is that it would "give us a national voice."

If we had this voice, what would we say? And if we said it, would anybody listen? We'd obviously have to say something very important to be heard at all, even though more people have been inclined to listen since last October.

There are important things to be said—about education, about technology and our civilization, about the H-bomb, automation, obsolescence. But does a civil engineer have authoritative opinions on all these subjects? Do mechanical engineers have the right to speak on all? And let us not forget the chemical, electrical, electronic, aeronautical, and other types. What of their varying political beliefs, sectional loyalties, differing ideologies and backgrounds?

Obviously, we'll have to get our opinions sorted out and agreed upon in advance.

Even the product engineer, to pick one specialized segment, is not a type. In all but a few cases, he is employed by someone else, and his opinions are very much those of his compatible fellow employes, with a greater or less amount of added knowledge on some specialized subjects. He is creative, and often introspective, so may be less likely than some others to have a positive and proclaimed opinion on public subjects. He is unlikely to be vocal on national or international politics.

Other engineers are likely to be quite vocal on such subjects—particularly where their livelihood is directly involved. Can such groups speak with one voice—except to reassure the layman that our new developments are not going to overwhelm him?

Among other licensed groups, there has been but little tendency to speak out—except in their own high-knowledge field. The C.P.A. is, for example, quite closely comparable to the engineer in background required. So is the licensed architect. Has either group spoken up? In medicine, with the strongest association of any, has there been any concerted voice—except on medical subjects such as socialized medicine or Salk vaccine? Of all professional men, only the lawyer has been heard—and in this case he delivers mainly his own views (or those of his party) as a political candidate.

So, given the "national voice," what would we say?

K. S. Vaugerman

candidate for economy . . .

THE SMALL GAS TURBINE

Are you overlooking advantages of this compact power package? Its small size and light weight promise increased use in many commercial applications. And it rivals the diesel in fuel cost when exhaust heat is put to work.

HANS ZIEBARTH, *Staff Engineer*
AiResearch Manufacturing Company

As starters for jet engines, these gas-turbine-driven compressors are compact, lightweight, easily transportable. Air Force also uses them for check-out and de-icing.

Take a data sheet for a small gas turbine and place it side-by-side with a sheet for a reciprocating engine of equal power output. At first glance the advantages of the turbine are rather startling: high power-to-weight ratio, inexpensive fuel, small size, negligible lubricant consumption, low maintenance cost, and freedom from need for cooling water. Aircraft manufacturers and designers of stationary power plants were quick to spot these tempting features and put them to work.

But the small turbine, at its present tender age, has some disadvantages. For example, compare figures for fuel consumption—1½ to 2 times that for comparable piston engines. And high rpm's result in a noise problem if inlet and exhaust are not carefully muffled. Life statistics are not well established (although small turbines have run for thousands of hours without major overhaul). Because of these drawbacks, engineers have been hesitant to specify gas-turbine power. There are applications, though, where the advantages outweigh disadvantages.

Potential Power Up the Stack

Fuel-consumption figures, for example, don't tell the whole story. A frequently overlooked feature of a gas turbine is that although it may burn up to twice as much fuel as a comparable diesel power plant, its air-to-fuel ratio is often about 3.5 times that of the diesel. This gives an exhaust-gas volume roughly seven times that of the diesel and, assuming equal exhaust temperatures, seven times as much waste heat. Furthermore, with less fuel per pound of air, the waste products have a higher oxygen content—approximately 80% that of free air.

The waste heat can be utilized two ways: directly, when both heat and shaft horsepower are required, or, utilizing its high oxygen content, as combustion air in steam generators or processing equipment.

Shaft Power Plus Heat

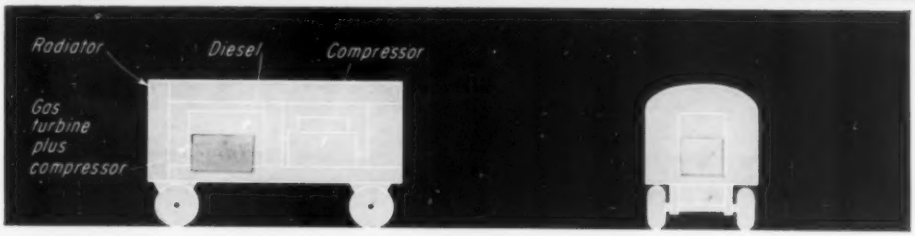
There are numerous examples of power-and-heat generators where the small gas turbine is ideal.

A desert power plant supplies 1500 kw and also produces distilled water. Its two small gas turbines give the needed shaft horsepower; and waste products are ducted to distilled water evaporators where they yield 4 tons of 330-F steam per hour. Using exhaust heat this way, and combining shaft power and heat in terms of btu/hr, output is 3.5 times that for a diesel plant of equal shaft hp, and over-all utilization of fuel by the turbine plant is about 80% compared with 60% for the diesel plant.

Another example is a portable plant for conversion of sea water. Here, the exhaust preheats sea water before it enters the still and a high-speed centrifugal compressor driven by the turbine compresses large volumes of steam to moderate pressures before condensation. With a 150-hp gas turbine, a daily yield of 40,000 gal. of processed water would be possible. In addition, a turbine-powered plant is smaller, lighter, and more easily transportable than its piston-engine equivalent. It is also independent of fresh water sources for cooling, and starts rapidly at both arctic and tropical temperatures—important features for equipment typically used in remote or arid regions, where equipment must operate despite climate extremes.

Compact Power for Portable Equipment

Gas turbines can be coupled profitably to other portable equipment even when exhaust heat is not fully utilized. Under these circumstances, the many



	GAS TURBINE PLANT Gas Turbine + Boost Compressor (without air coolers)	CONVENTIONAL PLANT Diesel Engine Only (without radiator)	Total Envelope (incl. enclosure & wheels)
Length, ft	4	4.5	15.5
Width, ft	2.3	2.4	7
Height, ft	2.3	3.6	9
Envelope, cu ft	21	39	980
Weight, tons	1.5	1	7

Size comparison . . .
between a diesel-driven portable air compressor and a bleed-and-boost unit powered by gas turbine. Both plants deliver 900 cfm at 115 psia.

advantages of small size, lightness, and freedom from cooling water make the turbine more desirable in spite of higher fuel consumption. And when exhaust gas is fed back to heat combustion air (recuperation), the difference in over-all fuel cost is often negligible.

Portable air compressors are an example. These machines commonly deliver air at 115 psia. With a gas-turbine drive, the alternative designs possible are: rotary or reciprocating compressor driven through reduction gears; direct-driven centrifugal compressor; or bleed-and-boost compressor, where air is extracted from gas-turbine compressor at about 60 psia and boosted to 115 psia by shaft-driven compressor. Comparing each alternative with a diesel-driven positive-displacement compressor shows advantages of turbine power for portable compressed-air plants.

Weighing Alternatives

If the turbine is geared down to drive rotary or reciprocating compressor, there will be some power losses through the gears. But the diesel also loses some power to the fan and cooling-circuit auxiliaries. Net result is that from the viewpoint of economy, the losses balance and fuel consumption for the turbine is, again, up to twice that of its reciprocating-engine counterpart. However, if a high-pressure (more efficient) turbine, or a medium-pressure turbine with recuperation is used, the difference can be cut from 2 times to 1.3 times or less. Furthermore, with a lesser grade of fuel and the turbine's negligible lubricant consumption, differences in operating costs might be eliminated altogether. Weight savings on the order of 1400 lb could be expected, assuming 150-hp engines for both.

Comparing a centrifugal compressor coupled directly to turbine shaft with diesel-driven rotary or reciprocating compressors, the fuel economy picture is even more attractive. Adiabatic efficiency of centrifugal compressors is about 80% compared with 65% for rotary or piston compressors. Fuel consumption of the turbine-driven compressor is only about 1.5 times that of the diesel plant and with recuperation it drops to a figure equal to or less than that of conventional equipment. And the turbines will decidedly outclass diesel-driven equipment in many construction and mining jobs when mobility, installation and operational advantages are brought into the picture.

Bleed-and-boost compressors are advantageous primarily because of their close-coupled design and resulting compactness. The boost compressor is usually of the positive-displacement type because bleed air has been previously compressed to a small volume. Interstage cooling is required but this can be accomplished with air-to-air coolers and an air-flow promoter driven by the turbine. Fuel consumption of bleed-and-boost compressors is slightly higher than that of the diesel-driven compressor.

Lightweight Air Conditioning

Small, compact turbine-driven compressors are expected to challenge conventional reciprocating machinery in other fields too. The transportation field is one of the most logical targets. Here, weight and size of mechanical equipment for auxiliary services is of great importance because the lightweight equipment makes more efficient use of space and demands less power to move it.

Recent experiments with railway equipment, such as the "lightweight train," indicate that some systems engineering will be necessary to relieve the serious predicament of designing vehicles for light weight and then loading them down with heavy, bulky auxiliary equipment to meet present-day standards of passenger comfort. Modern gas turbines will eventually figure heavily in such system thinking.

For example, consider a modern, transcontinental passenger train composed of lightweight, double-deck cars. For passenger comfort, each car requires a refrigeration system of 20-ton cooling capacity. With conventional air-conditioning equipment this means about 4 tons per car added to the train's traction load. Small, high-performance turbines and compressors could reduce this load to about 800 lb per car, cutting over-all tractive power requirements by 5% or more. Such a system would, of course, meet present standards of reliability, safety and economy. ■

those pipefittings with bearings . . .

SWIVEL JOINTS

MAY WORK WHERE NOTHING ELSE CAN

Here's your guide for choosing between swivels and other flexible connections such as rubber or metal hose. Swivels often supply the best answer where the joint must be strong as the pipe.

G. M. BAGNARD, *Chief Engineer, Chiksan Co., Brea, Calif.*

A flexible connection is a nuisance needed in any piping system that requires excessive movement. A nuisance because it adds to cost and may be a weak spot—and necessary because it can be manipulated where rigid piping cannot. Flexible rubber or metal hoses have the greatest degree of bending freedom, weigh least, and are usually lowest in initial price. But swivel joints often handle the pipe-joining job better because they are stronger and can negotiate tighter turns.

The conditions that call for flexible connections include: vibration, relative motion, thermal expansion, twisting and bending, need for frequent disassembly, multiple connections demanding a pipe or hose, and coupling that can be moved to several positions.

The choice between the two types of flexible connections depends on knowing the extremes of movement required, and matching them with cheapest components that meet service specifications (Table I). Other considerations are: fluid type being handled, pressure, temperature, geometry of installation, service (intermittent or continuous), pressure drop, and leakage. Bolting flanges—pipe- or straight-thread types—and welding flanges are available for either swivel joints or hose and seldom are problems.

One successful trick in many applications is to combine swivel joints with flexible hose. This retains hose versatility and—permitting easy rotation and reduced stresses—overcomes drawbacks of hose. End result is a saving in total pipe because tighter bends are possible.

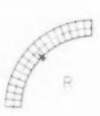
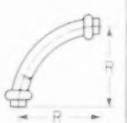
For use by themselves, the rubber or metal hoses can be made very limber or stiff—depending on wall thickness, materials used, and construction. They can be absolutely leakproof when specified. And they usually have no sliding parts—so wear of seals by grit or other contamination presents no problem.

But hoses are limited by strength and endurance. The greater the flexibility, the more delicate the construction, both for mechanical strength and for wear of hose by abrasion or corrosion (metal hose). A hose may be the weakest link in the piping system.

Twisting is a problem. For example, when one end of a hose is moved laterally, the hose twists. If excessive, twisting will eventually cause fatigue failure. Sometimes simple metal fittings are used at end connections to allow some rotation. However, under high pressure, the torque required to rotate one of these fittings may be greater than shear strength of the hose itself, resulting in a ruptured line. Another limitation: hose is elastic and kinks easily when bent in a short radius, Table II.

Rubber hose is not usually recommended at working pressures above 1000 psi. Flexible metal hoses are generally limited to pressures of about 750 psi, although reinforcement and several-ply construction can increase this to over 3000 psi. Even at relatively low pressures, 200 psi or more, a section of hose can become nearly as rigid as a piece of metal pipe.

TABLE II—Min Radius of Bend, in. (approx.)

OD, in	Hose		Swivel fitting
	Metal corrug	Rubber	
½	14	5	3
1	18	10	4
2	25	20	6
4	51	40	8
			

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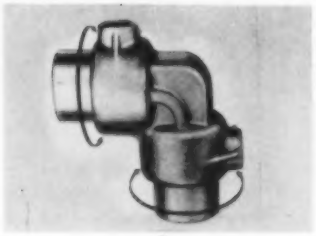

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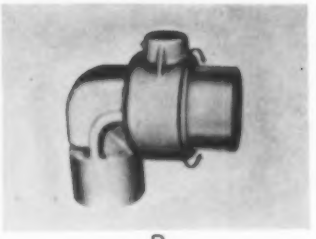

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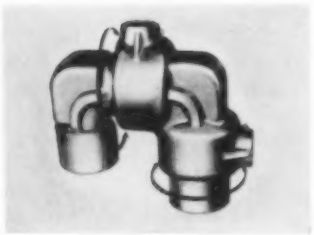

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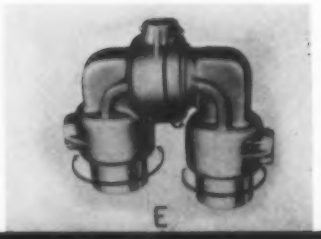

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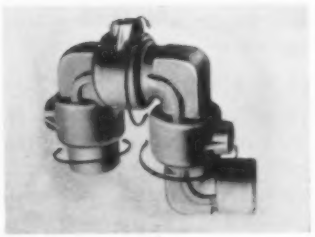

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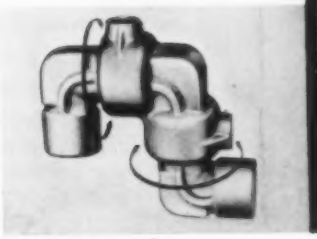


G

Table III – Styles of swivel joints

	No. of elbows	Planes of rotation
O	0	1
A	1	2
B	1	1
C	2	2
D	2	1
E	2	3
F	3	3
G	3	2

TABLE I—Over-all performance of hoses and swivels

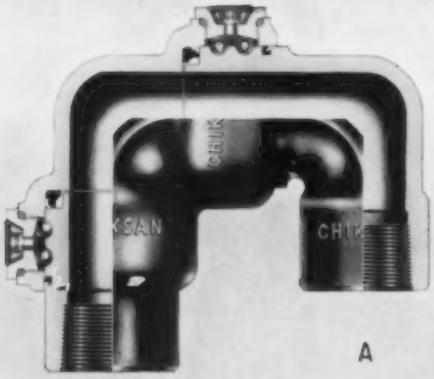
E—excellent *G—good* *F—fair* *P—poor*	Hose		Swivel Joints
	Metal	Rubber	
Max pressure	G	F	E
Flexibility:			
Force required	F	F	E
Planes of motion	G	E	F
Min bend	P	P	E
Safety	G	F	E
Fluids handled	F	F	E
Min pressure drop	F	G	G
Life expectancy	F	F	E
Weight	G	G	F
Leakage	G	G	F
Cost-(initial)	G	G	F

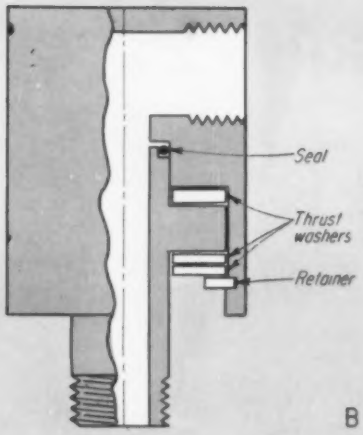
Rubber and most metal hoses using special materials can handle fluid temperatures up to 500 F without adverse effects. However, conditions of max temperature and pressure cannot be met simultaneously because the safe working-pressure level for hose decreases with increasing temperature.

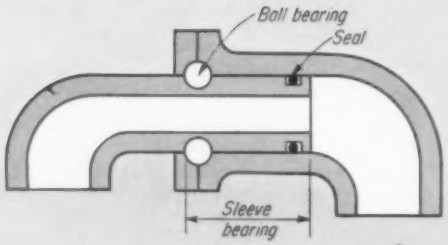
SWIVEL JOINTS

Rival to flexible hose is piping with joints that allow rotation or other relative movement, yet seal the contained fluid. They are constructed of steel, cast iron, bronze, aluminum or other rigid materials, and can usually withstand the same environment, pressures, and types of service as the rest of the piping system. Low-pressure joints operate from 28-in. vacuum to 1000 psi, and high-pressure joints to 15,000 psi. Most joints will work at 250 F, and special designs permit as low as −300 F or high as 1000 F. Corrosion is not too great a problem because there is a lot of material to corrode away. Small-radius bends are easily accommodated because the rotating joint is not part of the bend and therefore does not limit the bend radius significantly (Table II). A secondary advantage of a single-plane swivel is its movement in a predetermined arc and plane.

Almost any degree of freedom of movement can be







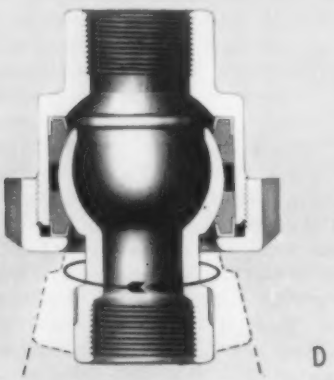


TABLE IV—Allowable cantilevered moments for high-pressure swivel joints with flame-hardened ball races.

Pipe size, in.	Moment, in.-lb	
	standard	special
2	6,525	.....
3	14,400	46,000
4	28,200	90,000

obtained by combining two or more joints. Single-plane swivels are common, but multiplane, spherical, or combinations of swivels and hose are available. Seven swivel joints will give unlimited flexibility. Sizes from ¼ to 36 in. dia can be built.

Two limitations to swivel joints are: difficulty in maintaining a leaktight rotating or sliding seal, particularly when installation and maintenance personnel forget that these are precision devices and require special care; relatively few planes of rotation available to any type except the spherical.

BEARINGS FOR SWIVELS

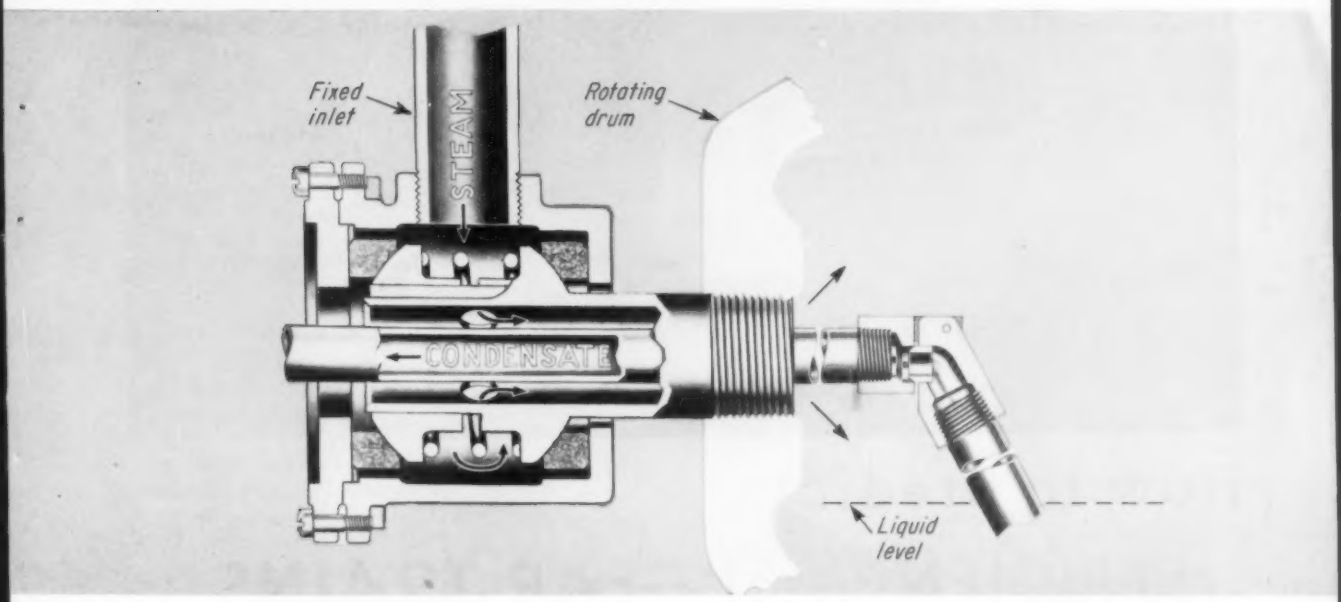
The joint itself may swivel on ball bearings, a spherical joint, thrust plates, or a bushing. The seal packing may also serve as the bearing in some applications. Full 360° rotation in the plane of the swivel is usually available, and the spherical (ball-joint) type may also pivot a total of 40° about its ball center.

Ball bearings are used to reduce torque without hurting smoothness. They have less wear than sliding bearings, and can carry thrust and radial loads simultaneously. Thrust loads come from thermal expansion and other forces exerted by the piping on the coupling, and from the internal fluid pressure. Radial loads are caused by weight of the piping, which also contributes a bending moment at the joint. With proper spacing between bearing races and careful choice of heavy-duty rolling elements, up to 90,000 in.-lb can be handled by a nominal 4-in.-dia swivel joint.

Thrust bearings (shoulders and washers) cannot take radial loads, and will not rotate freely if the axial load is heavy or cantilevered. Applications are for small-size hydraulic lines.

Sleeve bearings are satisfactory for light radial loads.

Bearing and seal . . .
design help determine application of swivel fittings. Style "C" swivel (photo A) features sealed bearings arranged to take heavy axial and thrust loads. Thrust-bearing type (B) and radial-bearing type (C) are for light duty; each can handle limited amounts of both thrust and radial loads. Spherical joint (D) has no metal-to-metal contact (ball seats itself in gaskets for either pressure or vacuum service) and flexing angle (dotted lines) can be 40° total.



Revolving joint . . .
allows steam to enter and condensate to leave revolving drum. Gasket-type spherical bearing also acts as seal, and loading is light enough to give long service. Drum bearings not shown.

Heavier loads increase torque considerably and accelerate wear. Axial loads cannot be taken.

Spherical-type fittings have circular gaskets that seal the joint and also act as spherical bearings. Each joint is self-aligning, but a single one should not be depended on to solve misalignment in other parts of the piping system. However, two will often correct misalignment better than three or more single-plane swivels.

CONTINUOUS ROTATION

Among swivel joints one type permits continuous rotation like that required when fluid from a stationary source is fed into a revolving drum. Special swivel fittings may be required for fast, continuous rotation, and knowledge of peripheral speed is important. The bearings and packings might be expected to meet certain velocity, low-torque, and low-wear requirements, in addition to those involving temperature, pressure, flow and mechanical stress. The larger the joint dia, the lower max rpm is allowed—this is to limit surface speed and help packing life. There are small joints designed for speeds to 10,000 rpm, pressures to 250 psi, and temperatures to 400 F.

For high temperatures, choose materials, packings and lubricants carefully, and borrow from the experience of manufacturers and users of standard high-temperature bearings as well as from swivel makers. The relationship between high-temperature and load-carrying capabilities of lubricants is complex, and expert advice is essential.

MATCH THE FLUID AND JOINT

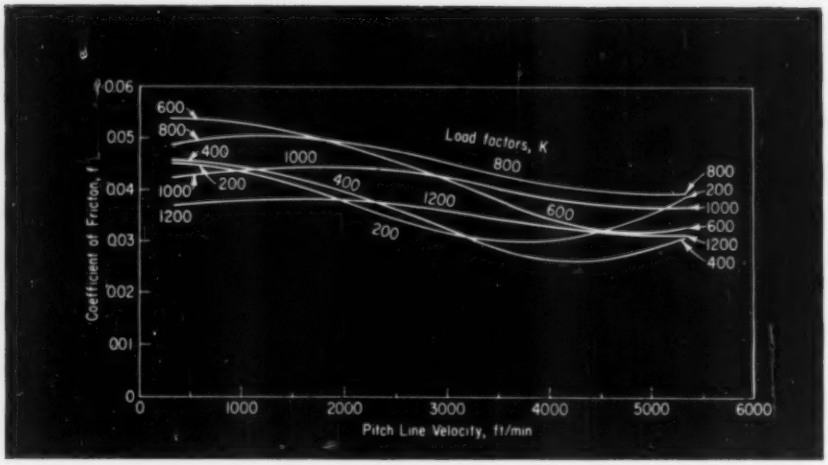
Fluid type influences material selection for swivel joints. Any metal is satisfactory for ordinary oils, alcohols, aromatics (benzene, napthalene, toluene), esters (acetates), natural gas, kerosene and so forth. Stainless steel, monel metal, or nickel-bronze should be specified for acids, mercury, molasses, and sewage. Asbestos chevron-type packing is suitable for the aromatics and esters, but Teflon or synthetic rubbers will be required for most of the other fluids mentioned above. The subtle effect of temperature, plus compatability problems, suggest that experts be consulted to assure proper material selection.

REPRINT of this article can be obtained for your reference file by checking No. E37 on one of the Reader Service cards bound in this issue. For other reprints available see "Current Reprints" listing in this issue on page 99.

EDITOR'S NOTE: Flexible connections have been the subject of frequent articles in the past: "Rotating Joints," Aug '56, p 200, details many applications for swivels on rotating drums and other moving components; "Rotating Seals for High Pressure," Feb '56, p 140, shows how to design seals and select proper materials; "Metal Hose," Nov 11 '57, p 87, summarizes range of application of stripwound and corrugated hose; "Pressure Losses in Flexible Metal Tubing," Apr '56, p 223, helps with flow calculations.

Related articles on piping, fittings, valves and pressure drops are: "Maintenance Advice for Fluid Circuits," Mar 17 '58, p 71, a detailed summary of important precautions; "How Much Hp to Pipe Liquids," Jan 6 '58, p 89, helps estimate circuit power losses; "Updating the K-factor," Apr 14 '58, p 74, simplifies pressure-drop calculations in valves and fittings; "Quick Disconnects and Self-sealing Couplings," Dec '55, p 168, a roundup of couplings, some of them swivel-type.

And look for coming article: "How to Design With Swivel Joints."



1 Coefficient of friction in . . . mating gears varies with load and speed. Curves are for 20° pressure angle, case-carburized and ground spur gears, with average lubrication fed in at 120-F inlet temperature.

How to predict EFFICIENCY of GEAR TRAINS

The sliding action of involute gear teeth causes a power loss. It can be computed from new formulas and test data given here.

EUGENE E. SHIPLEY
Advance Gear Engineering, General Electric Co., Lynn, Mass.

LIST OF SYMBOLS

- D — pitch dia of pinion, in.
- E — efficiency of gear mesh, %
- f — coefficient of friction, dimensionless
- F — face width of thinner gear, in.
- H — specific sliding velocity of teeth (ratio of sliding velocity to pitch-line velocity); subscript s denotes value during start of approach, subscript t during recess action
- K — load factor or index to tooth loading
- n — pinion speed, rpm
- N — gear ratio where $N = 1$ or larger
- P — power loss of gear mesh, %
- r — pitch radius of pinion, in.
- r_b — base radius of pinion, in.
- r_o — outside radius of pinion, in.
- R — pitch radius of larger gear, in.
- R_o — outside radius of larger gear, in.
- s — path of approach, in.
- t — path of recess, in.
- V — pitch-line velocity, ft/min
- W — driving load at pitch radius, lb; W_t = tangential component; W_n = normal component
- Z — friction force; $Z = f W_n$
- θ — pressure angle, deg
- ω — angular velocity of pinion, rad/sec

New formulas and test data now make it possible to acurately predict power losses in gear meshes. Knowing such losses will help select oil reservoirs, pumps and coolers of proper capacity. Also, gear-mesh losses may make a difference when deciding on size of the power source.

The losses are important enough to warrant attention even though gears give high power-transmitting efficiency—in the upper 90% range. Almost all the energy loss is converted into heat. In high-power applications, this affects size of the lubricating system which removes much of the heat.

This Equation Does It

Gear-tooth surfaces move across each other with a combination of rolling and sliding motion. Therefore, the loss is a function of the average sliding motion and coefficient of friction. In terms of percent power loss for a simple set of gears, the power formula is

$$P = \frac{50f}{\cos\theta}\left(\frac{H_s^2 + H_t^2}{H_s + H_t}\right)$$

where

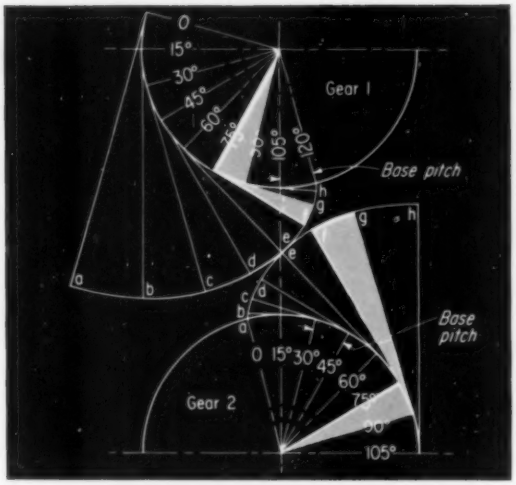
$$H_s = \left(\frac{N+1}{N}\right)\left(\sqrt{\frac{r_o}{r} - \cos^2\theta} - \sin\theta\right)$$

and

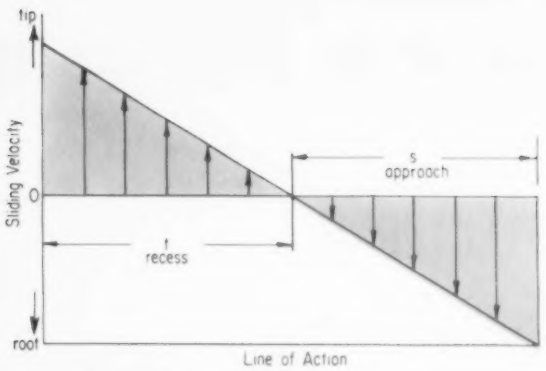
$$H_t = (N+1)\left(\sqrt{\frac{R_o}{R} - \cos^2\theta} - \sin\theta\right)$$

The percent efficiency is then:

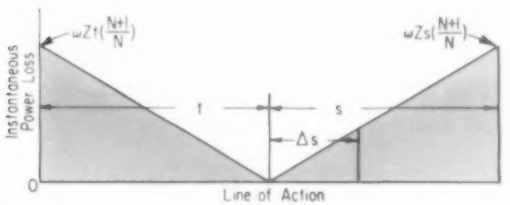
$$E = 100 - P$$



2 Involute profiles . . .
of mating teeth have unequal segments, causing a sliding as well as rolling action.



3 Sliding velocity . . .
between mating teeth varies from max values at tip and root of tooth, to zero at pitch line.



4 Instantaneous power loss . . .
is proportional to sliding velocity. Shaded area represents average power loss.

All factors above are easily determined from geometry of the gear system, with exception of the coefficient of friction f. A common value for lubricated case-hardened and ground gears has been $f = 0.06$ but lengthy tests now show it to be on the conservative side. More accurate values, given in chart, Fig. 1, are based on various load factors K and pitch-line velocities V, which in turn are computed for a particular gear set from these two equations:

$$V = 0.2618Dn$$

$$K = \frac{W_t}{F\,D}\left(\frac{N+1}{N}\right)$$

Nature of *f* Curve

The chart shows that for any given load factor, f starts out high, dips to a minimum, then climbs again. These curves follow hydrodynamic theory in that high friction values occur during boundary lubrication conditions and then dip and climb with continued increase in speed.

Additional tests are underway by the author to study the effects of higher speeds, improved surface finishes, viscosity changes and temperature variations on the coefficient of friction.

The Sliding Motion

In normal operation there is always some sliding motion between gear teeth—an inherent characteristic of involute gearing. The involute profiles of the mating teeth can be developed by unwinding a string from a base circle while keeping it taut, Fig. 2. For two involute gears to transmit a smooth and constant angular motion, the base pitches of both must be equal. However, the equivalent segments on the involute profile are not constant—being very small at beginning of development (segment *gh* for gear 1 and *ab* for gear 2), and growing larger toward the tooth tips (segment *ab* for gear 1 and *gh* for gear 2).

Thus, for both gears to have equal angular displacements during operation, segment *gh* on gear 1 must correspond to segment *gh* on gear 2, and sliding motion (in addition to rolling motion) occurs. Sliding velocity is a maximum at the first point of contact, reduces to zero at the pitch dia, changes direction and increases again to a maximum at the last point of contact, as shown in Fig. 3. For a 1:1 gear ratio, max values at both ends are equal, and length of recess action equals length of approach action.

Deriving Power Formula

The instantaneous power loss is proportional to the sliding velocity. Total power loss for a single-tooth engagement is represented by the shaded area in Fig. 4. Average power loss P_L is

$$P_L = \frac{\omega Z}{(s+t)}\left(\frac{N+1}{N}\right)\left(\int_0^s s\,ds + \int_0^t t\,dt\right)$$

which gives

$$P_L = \frac{\omega Z}{2}\left(\frac{N+1}{N}\right)\left(\frac{s^2+t^2}{s+t}\right)\ \frac{\text{ft-lb}}{\text{time}}$$

Average power transmitted is

$$P_T = \omega W_a r_b$$

The percent power loss P is then the ratio of P_L to P_T, multiplied by 100. This ratio, when substituting values for s and t results in the power formula given on the previous page.

EDITOR'S NOTE: In a recent issue, Jan 6, p 77, Mr. Shipley described 12 ways to load-test gears, including one developed at the GE plant at Lynn.

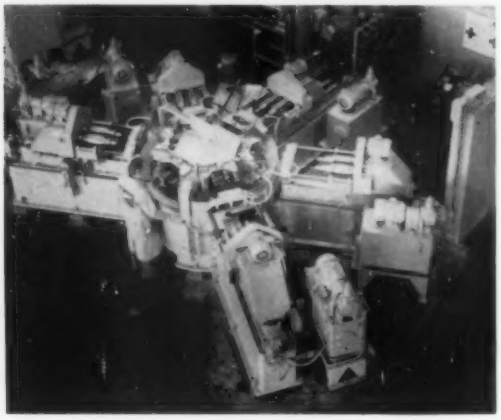
Planetary gear trains are affected by "Coriolis Acceleration—a Force to be Reckoned With," May 26, p 72.

DESIGN FEATURES

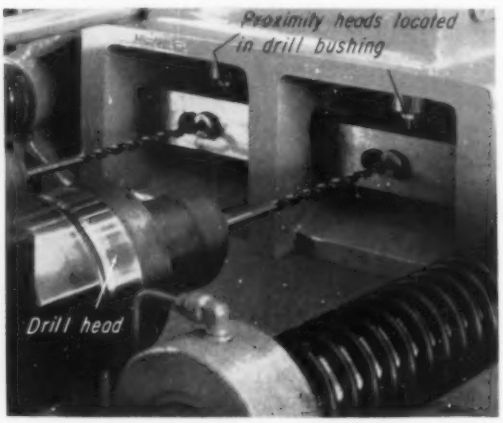
ELECTRONIC FINGER CHECKS DRILLS

Proximity control unit here does a continuous inspection job that protects automatic operations. Broken drill halts machining cycle; turns on red light that locates the trouble.

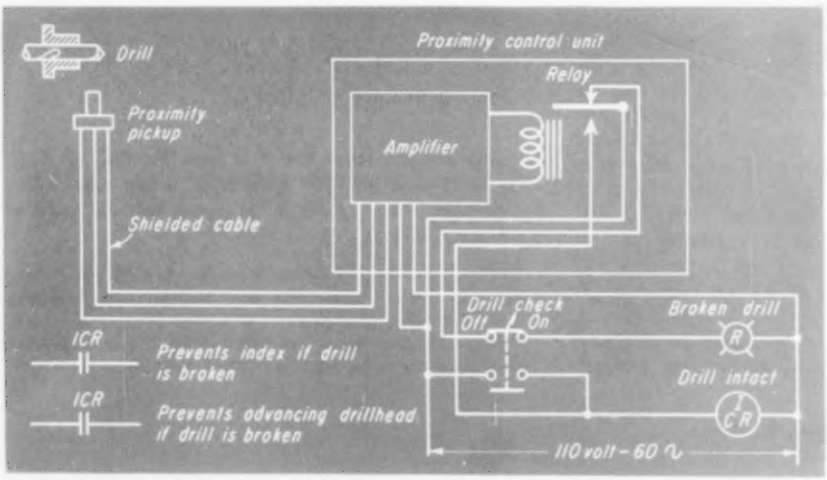
This proximity detector is incorporated in five-station, dial-type automatic designed by Buhr Machine Tool Co., Ann Arbor, Mich. It does away with need for inspection stations usually required in such automatic operation.



To prevent binding . . .
tool diameter drops in five steps—from 0.290 in. to 0.257 in.—as this dial-type automatic machine drills deep oil passages. And drill length increases from 9 7/8 in. to 16 in. as hole deepens. With drills becoming longer and thinner at each station, breakage problem is intensified—drill broken off in work at one station could break all following drills if not detected immediately. Job of the proximity control unit is to stop recycling and detect broken drill.

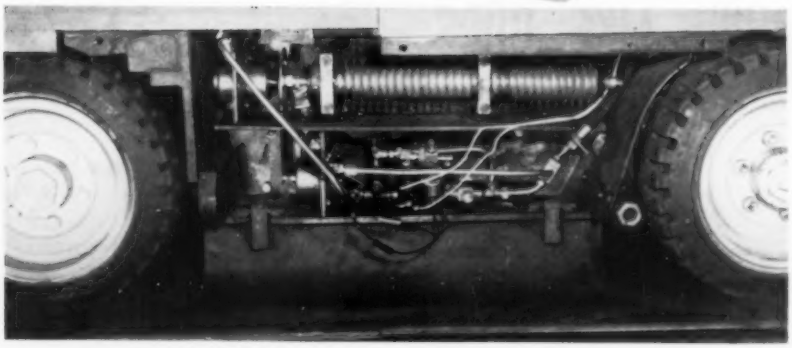


Small induced current . . .
in detector is amplified to activate a relay. Broken drill interrupts current, trips relay, turns on fault light and halts machine cycle. Light locates trouble for immediate correction by operator. Broken drill is replaced and damaged part removed. Drill head is restarted and machine returns to automatic cycle.



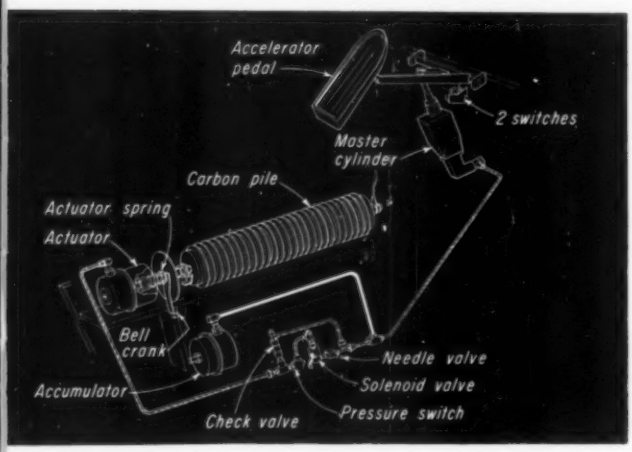
RESISTOR SMOOTHS LIFT-TRUCK DRIVE

The jerky starts associated with step control for electric drives are eliminated here—a hydraulically actuated carbon pile gives infinitely variable speed control up to ¾ full speed.



This forklift, CE-20, produced by Industrial Truck Div. of Clark Equipment Co., Battle Creek, Mich., loads up to 2000 lb lifted at 50 fpm. It can travel at 6.5 mph in either direction.

Hinged panels . . . ▲ make it easy to get to control components—or remove the entire control unit intact. Another feature is interchangeability of parts with the company's gas-driven forktrucks. Common parts include steer axles, drive-axle ends (including brakes, wheels, tires), cowl, control-lever mechanism, adjustable seat, and lift mechanisms.



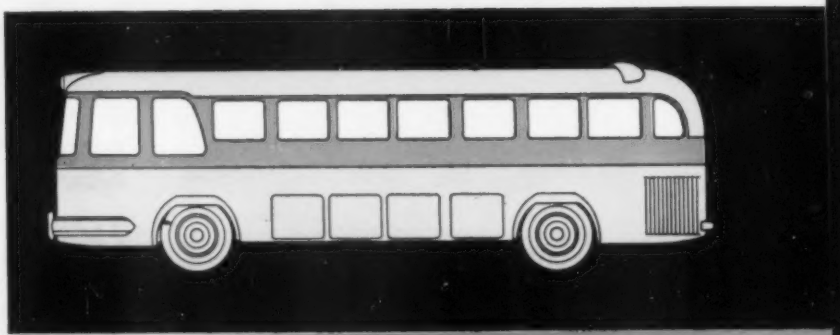
Truck speed . . . is controlled by effect of accelerator pedal upon hydraulic circuit that governs electrical input to drive motor. When accelerating, oil goes from master cylinder and through needle valve, solenoid valve and pressure switch to the actuator. Here, a piston compresses the carbon pile, decreasing its electrical resistance. Excessive acceleration is prevented by needle valve that bypasses oil to accumulator. Releasing the pedal returns oil through check valve to master cylinder. For top speed, the preset pressure switch shorts-out the carbon resistor. This, and deactivating the low-speed field coils, takes a minimum of 6/10 sec.

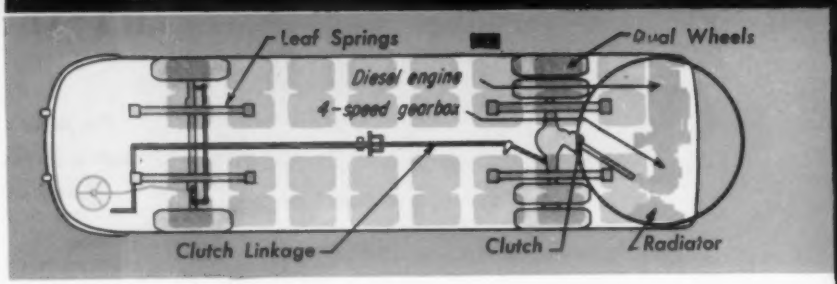
Depressing the pedal activates a switch that prevents plugging when directions are reversed. A second switch, which trips when pedal is 1 in. from the floor, works in series with pressure switch; assures max pressure has been applied to the carbon pile before shorting it out.

Braking, without spilling loads, is done by changing directional control to reverse. This applies limited reverse voltage to the drive motor and actuates the solenoid valve. Depressing the accelerator before the truck has stopped bypasses oil to the accumulator. The accumulator bell crank applies limited pressure to the carbon pile until the truck slows sufficiently to de-energize the solenoid valve; then normal operation in reverse is possible.

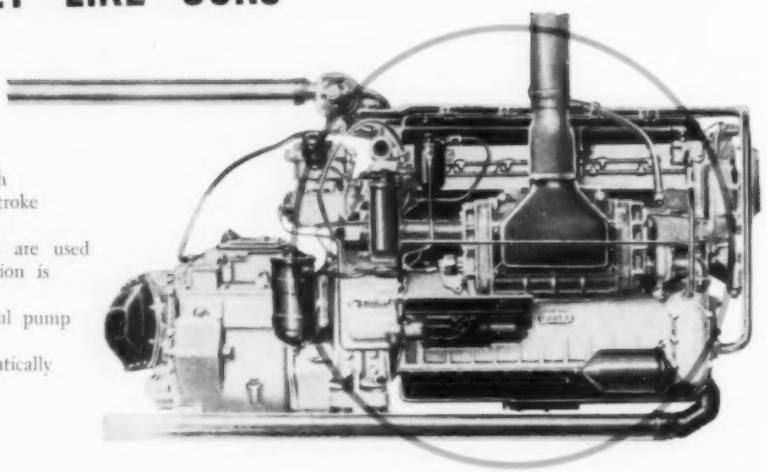
This 1959-Model produced in USSR would pass unrecognized in the US. Its family resemblance to American counterparts results from Russian practice of adopting designs if available.

One of the many interesting items brought back from his recent trip to Moscow by our Chief Editor, E. J. Tangerman, was a folder describing a long-distance bus produced in the Soviet Union. Printed in English, Russian, French and German, the full-color, profusely illustrated brochure was obviously intended as sales literature for satellite countries. The bus is produced by the Likhachjov Automobile Works, Moscow, Russia.

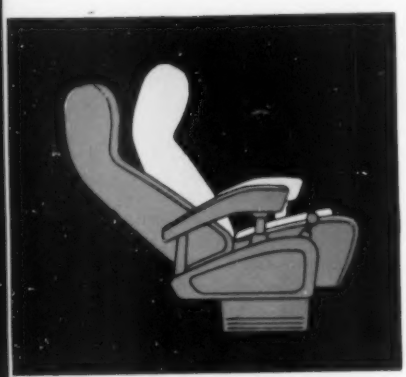




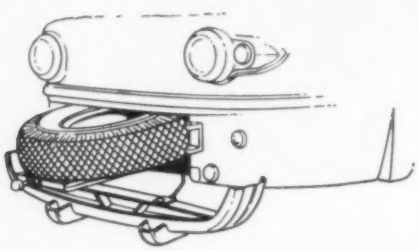
MOSCOW'S BUS BUILT LIKE OURS



Power is provided . . .
by a 2-stroke, 6-cylinder, supercharged diesel with direct fuel injection. The 4.21-in. bore, 4.95-in. stroke engine develops 180 hp at 2000 rpm with a 16:1 compression ratio. Thin-wall lead-bronze inserts are used for main and connecting rod bearings. Lubrication is provided by a double gear pump, two oil-cooling radiators plus coarse and fine filters. A centrifugal pump circulates cooling water through the engine and radiator—the latter is equipped with thermostatically controlled louvers.



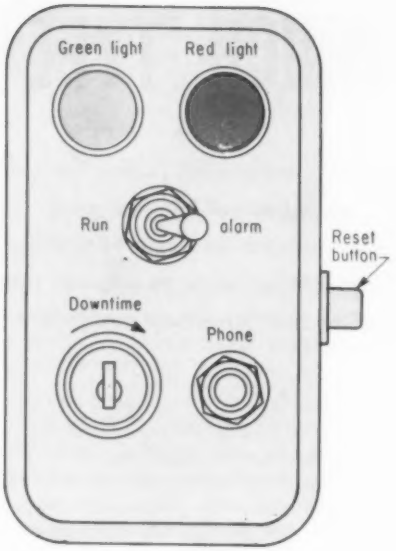
Details of trim . . .
are principal clues that distinguish the ZIL-127 from thousands of buses in daily American use. The resemblance is hardly accidental—Rusisans freely admit to borrowing proven designs for equipment they need immediately. The savings in both engineering manhours and development time is obvious. Passenger comfort features include: adjustable reclining seats, pushbutton radio, and fresh-air-circulating heaters. Technical details include: power steering; 12-v electrical system supplied by a 2000-w alternator with a selenium rectifier; curved triplex safety plate windshields; and rear-mounted engine.



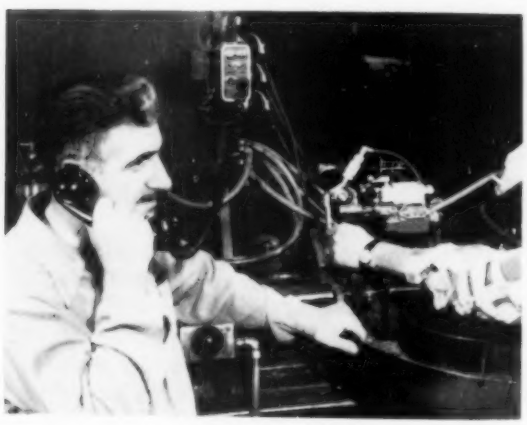
CONTROL PANEL SPEEDS FOREMAN TOO

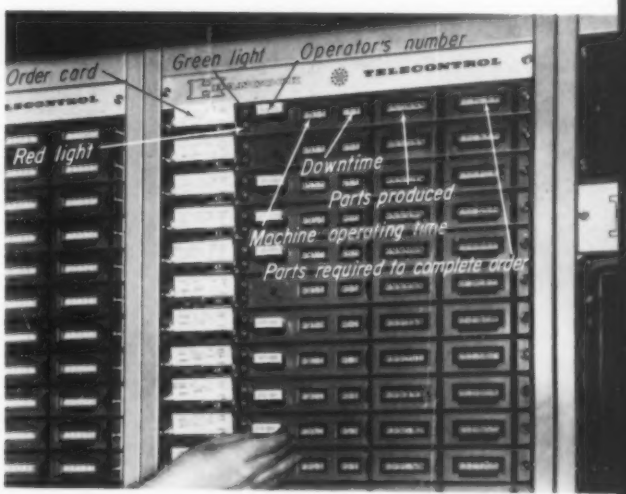
Besides tabulating production of parts, the panel works in conjunction with PA system and circuit of colored-light signals to keep supervisory personnel in touch with trouble spots.

Components of electrical network linking production machines with dispatch room are simple, but keep management in fast control of every operation. The control system was developed by Control Systems Co., a Div. of Hancock Industries, Inc., Jackson, Mich.



Control box . . .
at each production machine relays information to control dispatch station for tabulation by counters. When the machine is operating, both control box and dispatch counter display a green light. If help is needed, machine operator flips toggle switch to "Alarm"; green light stays on but red light flashes at control box and dispatch station. Dispatcher calls foreman on PA system and directs him to signalling machine. If machine must be shut down, foreman uses key to operate downtime lock on control box. This puts red light on steady, disconnects production counter and turns on downtime counter in control room. When machine resumes operation, worker pushes reset button—it turns out red light in control room and reactivates production counters. Telephone jack on control box permits foreman to talk to dispatch room with portable phone carried on his belt.



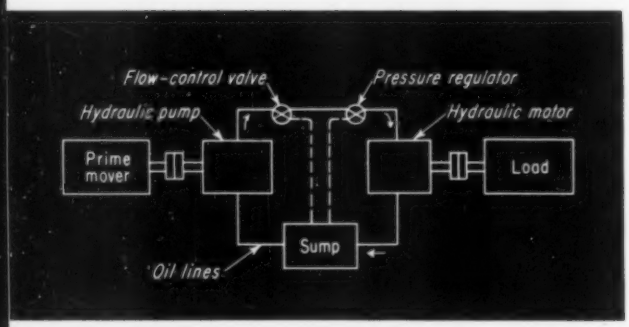


Display panel . . .
has colored lights and four electromechanical registers. As long as green light is lit, production register shows time elapsed; "parts" register indicates pieces produced; balance register subtracts from total of parts needed. When foreman turns his key, red light goes on, productive register halts and downtime is indicated in fractions of hours. Display panel is inoperative until dispatcher inserts plug with operator's number. Master clock may activate system at start of shift, turning on green light at each machine. All data may be transferred to tape at end of shaft for use by other management departments.

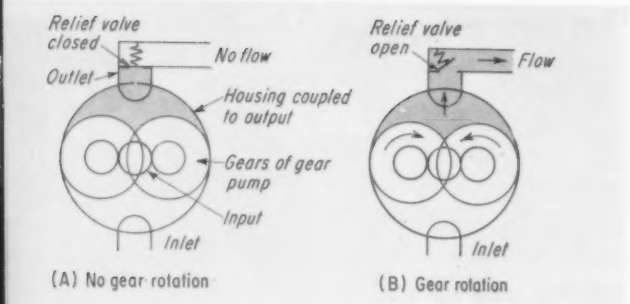
WHICH TYPE OF

R. A. BAREISS, *Senior Project Engineer*
P. A. BRAND, *Project Engineer*
Lessells and Associates, Inc., Boston

Hydraulic . . . magnetic . . . mechanical . . . electromechanical? In text and table the authors analyze 17 conventional and newer ways to prevent motor overloading and strain on equipment.



Hydrostatic transmission . . .
limits torque by converting mechanical energy to hydraulic energy, then regulating the hydraulic pressure and flow.



Hydrostatic coupling . . .
employs gear pump between prime mover and load. Input is coupled to gears of pump; output to housing. In normal operation (A), spring keeps relief valve closed and gears cannot rotate—coupling is "locked up" and there is no slippage between input and output. Under overload (B), relief valve opens, gears rotate relative to the housing and slippage occurs. Oil is scooped into inlet side during rotation.

This analysis of torque-limiting devices was made in connection with research undertaken for the US Navy's Bureau of Ships. In general, such devices prevent overloading of motors and act as safety devices by preventing strain on the mechanism, tool or equipment being powered. In this particular project, the search was for a satisfactory unit to limit torque transmitted to boat winches, and thus prevent a cable from snapping when overloaded.

Some of the devices analyzed are standard off-the-shelf items with inherent characteristics that permit direct installation without modification. Others require modification. And a few were specially designed by the authors and their associates.

Specifications called for (1) limiting torque to a preset maximum between 120 to 200 ft-lb, (2) giving such limitation that would be effective for both directions of rotation, (3) resetting without disconnecting the drive. Comparison of cost and sizes, therefore, are made on this basis, but can be extrapolated to meet other specifications.

HYDRAULIC DEVICES

Hydrostatic transmission employs a variable-displacement hydraulic pump, constant-displacement hydraulic motor, and pressure-compensating or relief control. This circuit limits torque by limiting hydraulic pressure and flow, but needs high internal pressures, up to 3000 psi, for efficient operation. Power load on the electric drive motor can be controlled by torque requirements of hydraulic motor; therefore, there is little necessity for a large heat sink. At speeds approaching zero, internal leakage reduces torque of hydraulic motor so that torque is no longer a linear function of oil pressure.

Hydraulic pumps and motors are sized and priced mainly by flow capacity. In this application, however, machinery must be sized to provide the required flow at high speeds and required torque at lower speeds.

Hydrostatic coupling—here a torque-sensitive coupling is obtained by connecting the load shaft to the casing of a hydraulic gear pump, the input shaft to the gear train, and using a pressure-relief valve on the outlet side of the pump. Pump gears cannot turn as long as relief valve is closed; overload builds up pressure to open relief valve which permits slippage. Torque limitation is valid

 REPRINTED—circle E36, inside back cover

TORQUE-LIMITING DEVICE?

in both directions of rotation. Centrifugally operated valves will prohibit the load from turning a dead motor. Some leakage will occur within the gear motor, resulting in a limited amount of slip—estimated considerably below 5% at 1800 rpm.

For heat dissipation, the relief valve will vent against an outer stationary, finned housing; the bottom of this housing will act as oil sump. A constant-viscosity oil will minimize temperature sensitivity.

Hydrokinetic couplings are of fluid-clutch type using very high fluid flow rates at low internal pressures. Nominal slip of 3% to 5% is required at rated conditions and the torque transmitted increases with slip speed.

Heat buildup is relatively severe at high slip speeds. Torque-transmitting characteristics are dependent upon fluid viscosity. A simple hydrokinetic coupling does not appear to be satisfactory for this application.

Variable hydrokinetic coupling. By permitting one element of a fluid clutch to move in an axial direction at the command of a torque-sensitive member of the drive train, the effective torque transmitted can be held essentially constant. Cam positioning of the coupling element in response to reaction against a torsional spring would be the torque-limiting action. A relatively constant-viscosity oil is recommended. Size and cost data on this type of coupling have not yet been evaluated.

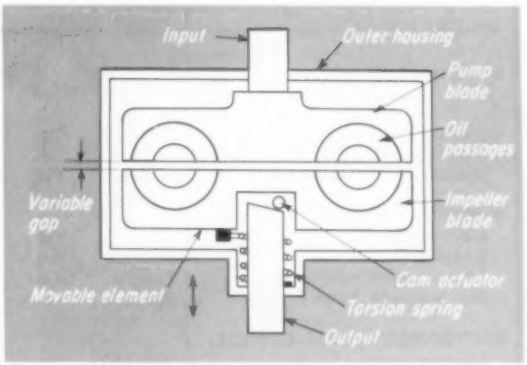
MAGNETIC DEVICES

Electrostatic couplings—manufacturing clearances and design ingenuity required to limit torque in electrostatic type couplings are extremely rigorous and unsuitable to this application.

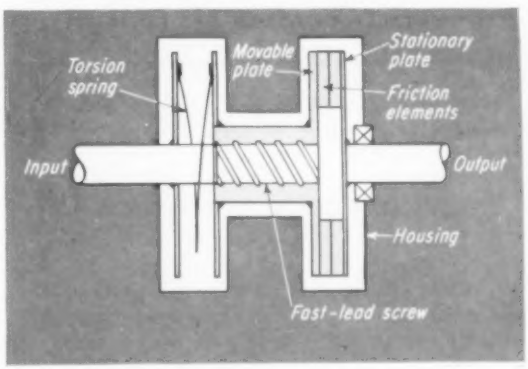
Eddy-current couplings have an abruptly increasing and then slowly decreasing torque as a function of slip speed—but this is not too severe for the application considered here. Torque limitation is by either constant or speed-regulated rotor dc excitation. Slip capacity and ability to dissipate heat is very high. This is an off-the-shelf item but a special casting is necessary to enclose the coupling between drive motor and gearing, and dc electrical connection to the coupling is required. Salt-air atmosphere may effect the slip-ring performance.

Eddy-current, self-excited couplings require no electrical connections. Radially mounted Alnico permanent-type magnets provide the necessary field flux. Cost is about half that of conventional eddy-current couplings.

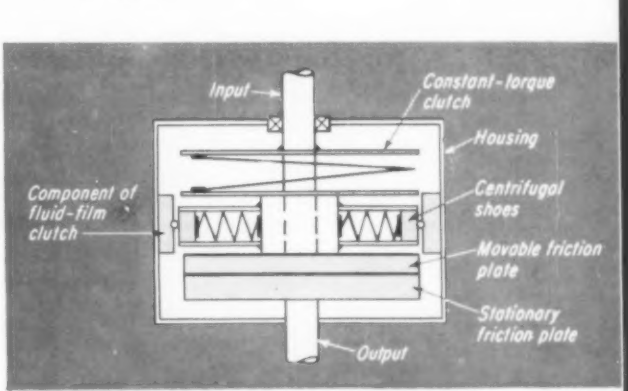
Dry magnetic powder clutches have constant torque



Hydrokinetic coupling . . .
employs a torsion spring to vary gap between blades of a standard fluid clutch. Torsion spring wraps up under load, pulling impeller blade away from pump blade to increase slip.



Torsion spring . . .
is key element in constant-torque clutch. Spring winds up under load and pulls back movable friction plate, causing slippage.



Dual-torque clutch . . .
connects the constant-torque clutch and fluid-film clutch in parallel. This reduces heat buildup during slippage and increases maximum load capacity.

WHICH TYPE OF TORQUE-LIMITING DEVICE?

TORQUE-LIMITING DEVICES—A COMPARISON . . .

METHOD	Torque Limits, max/ stalled	Self-resetting	Bi-directional Operation	Self-contained	Reliability	Length & Dia, in.	Weight, lb	Cost, $ (estimated)
HYDRAULIC DEVICES								
Hydrostatic Transmission	200/200	Yes	Yes	Yes	Good	30 x 15	1800	4000
Hydrostatic Coupling	200/200	Yes	Yes	Yes	Good	15 x 11	100	1500
Hydrokinetic Coupling	75/200	Yes	Yes	Yes	Good	.....	....	300
Variable Hydrokinetic Coupling	75/200	Yes	Yes	Yes	Good	.....	....	....
MAGNETIC DEVICES								
Electrostatic	.....	Yes	No	No; dc	Excellent	.....	....	....
Eddy-current	200/120	Yes	Yes	No; dc	Good	18 x 19	475	1100
Eddy-current, self-excited	145/93	Yes	Yes	Yes	Excellent	27 x 16	250	600
Dry Magnetic Powder	200/200	Yes	Yes	No	Good	20 x 12	230	1000
ELECTROMECHANICAL DEVICES								
Electromagnetic Friction	200/140	Yes	Yes	No	Good	3¼ x 6½	40	400
Friction Current-limitation	200/200	Yes	Yes	No	Fair	.....	....	....
MECHANICAL COUPLINGS								
Slip Clutch	200/140	Yes	Yes	Yes	Fair	8½ x 10¼	40	150
Constant-torque Clutch	125/125	Yes	Yes	Yes	Excellent	4½ x 6½	30	250
Fluid-film Clutch	200/4	No	Yes	Yes	Excellent	3 x 9½	....	....
Dual-torque Clutch	200/80	Yes	Yes	Yes	Excellent	6 x 9½	....	....
Cam and Roller Couplings	200/0	No	Yes	Yes	Good	8 x 7½	....	....
Centrifugal Friction	200/120	Yes	Yes	Yes	Good	4 x 7½	30	85
Centrifugal Dry-fluid Clutch	165/120	Yes	Yes	Yes	Excellent	4 x 9½	30	90

capability at a constant dc field excitation but cannot take 100% slip for more than 5 sec.

ELECTROMECHANICAL DEVICES

Electromagnetic friction clutches can limit torque by employing low power dc for field excitation. Slip capacity is relatively low; slip accuracy and predictability is somewhat questionable under severe storage and environmental conditions because the friction surfaces can corrode.

Current-limitation is another electromechanical torque-limiting method. It employs a mechanical torque-sensing device (perhaps a flexible member in the drive train) to operate a drive-motor current limiter. Calibration and maintenance of such a system are the major drawbacks. Cost and size information have not been developed for this device.

MECHANICAL DEVICES

Slip clutches—because a friction plate slip clutch has the inherent characteristic of a higher static friction than sliding friction, variations in breakaway torque are large—usually ±20%. Some slip clutches can withstand 100% slip for more than one minute without serious damage. Friction elements are of molded asbestos and the effect of long disuse in a salt atmosphere is unknown —though it will probably add to the inaccuracy of breakaway torque.

Constant-torque clutches are available with a torsion spring and fast-lead screw to load the movable element of a friction plate clutch in an axial direction. A "dry" clutch is employed because the friction-surface protection and heat-dissipation advantages of "wet" operation are unnecessary. Torque is limited in only one direction of rotation. Clutch acts as a solid coupling in the other direction, which is satisfactory for applications where jamming during the reverse operation will not damage the equipment or endanger human life.

Fluid-film clutch has radially mounted metal shoes that pivot so that when slip occurs a relatively friction-free wedge of fluid is built up rearwards from the leading edge. When shoe and drum are again synchronized, the oil wedge is squeezed out and the coupling will carry its full design torque.

This type clutch was developed by the Polaroid Corp., which also holds a patent on it. It is not available on the market.

Dual-torque clutch combines constant-torque clutch with fluid-film clutch to give a coupling that has two values of torque transmission. This idea has not yet reached production stage. Clutches are connected in "parallel"—so that input side of each clutch is directly connected to the motor shaft and output side of each to the load. In operation, the constant torque clutch would be sized to handle independently the pick-up load. This would bring two members of the fluid film clutch into synchronization and full lock-up or torque transmission. The unit would then transmit a torque

OF CHARACTERISTICS

100% Slip Duration, sec	Adjustable Torque Limit	Development Cost	Availabilit
60+	Yes	Low	Composed of standard po- nents
60+	Yes	Low	New idea—specially design
....	Yes	None	Standard item
60+	Yes	Medium	Standard Item—modified
60+	Yes	None	Standard item
60+	Yes	None	Standard item—modified
60+	Yes	None	Standard item
5	Yes	None	Standard item
2	Yes	None	Standard item
60+	Yes	None	Standard item—modified
60	Yes	None	Standard item
60+	Yes	None	Standard item
60+	Yes	Low	Patented item, but never produced
60+	Yes	Low	New idea—not in production yet
60+	Yes	None	Standard 'tem
60	No	None	Standard item
45	Yes	None	Standard item

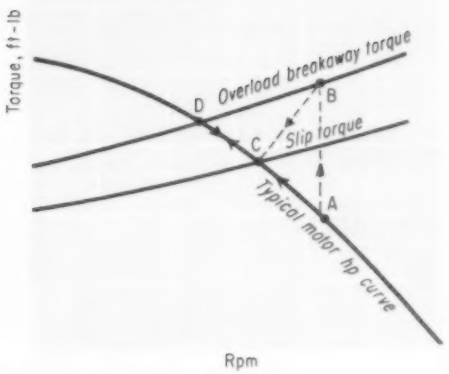
equal to sum of maximum torques of each of them separately. The lower torque capacity of the constant torque clutch will be sufficient to pick-up the load, and in combination with the fluid film clutch will provide overload torque capacity.

If this maximum torque is exceeded, the constant torque clutch will begin to slip. The fluid film clutch would slip simultaneously and its torque capacity would drop to zero. Full lock-up of the unit would occur again when the load torque dropped below the rating of the constant torque clutch alone. In this way the power (heat) to be dissipated during a jammed condition would be reduced to a minimum while still providing for picking up the load without stopping the motor or manually resetting the coupling.

Centrifugal friction-type clutches are speed sensitive. The maximum torque the clutch can transmit is reduced as the drive motor is slowed down under load. Heat dissipation and heat capacity is higher than for the comparable disk clutch. Corrosion of the friction surfaces can seriously affect performance. Torque capacity is not readily adjustable.

Centrifugal dry-fluid clutches use a charge of steel shot in a rotating housing to clamp and hold a mounted disk rotor. The clutch is speed-sensitive in that the breakaway torque decreases with decreasing input shaft speed. Further, at a given input shaft speed the full slip torque is approximately 75% of breakaway capacity.

How the clutch responds as a function of load characteristics is shown in operation curve above. Assume the drive operating at a torque speed relationship defined by point *A*. With a sudden increase in torque (or load) output torque of the transmission will rise instantaneously with virtually no drop in speed to point *B*, the breakaway-torque value. The clutch will then begin to slip, torque capacity will drop to the full slip line at the point of intersection with the motor curve, point *C*. The clutch will again transmit power when the load torque is relieved to this value or lower.



Operation curve . . .
of a centrifugal dry-fluid clutch, showing speed variations under overload conditions.

However, if the load is increased gradually, the torque-speed relationship will proceed from point *A* to point *D*. Torque transmitted will then drop to the full-slip value with little change in speed, and equilibrium will be reached at the intersection of the full-slip curve with the motor curve at point C as before—and re-engagement will occur.

If the unit can be designed or sized such that the breakaway torque at impact load does not exceed the maximum permissible load, the unit will be "fail-safe" in that all other torque values at breakaway are lower.

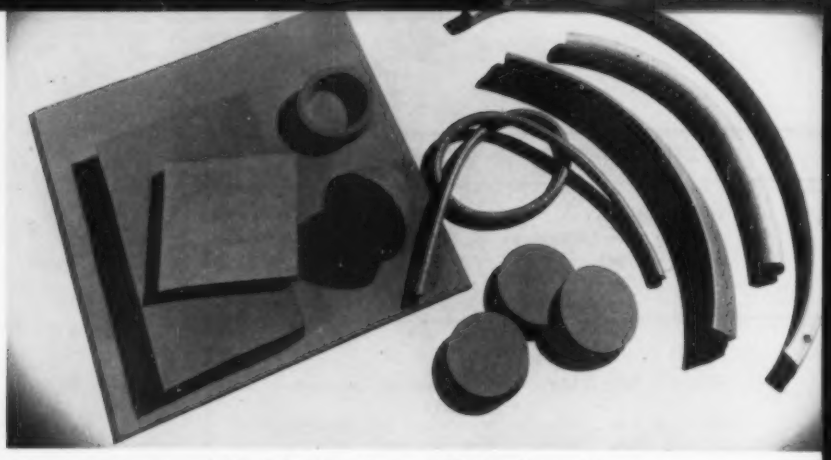
This clutch is adjustable, can be set and sealed at the time of manufacture. A thermal shutoff device is available which can stop the drive motor if there is critically severe overheating of the clutch. This does not seem required for the usual abnormal operation, which involves 100%-slip durations of less than 45 sec followed by 10 to 15 minutes of cooling period.

REPRINT of this article can be obtained for your reference file by checking No. E36 on one of the Reader Service cards inside back cover. For other reprints available see "Current Reprints" listing in this issue on page 99.

EDITOR'S NOTE: A similar problem, but one that may require an entirely different solution, is to team together a high-acceleration power source and a machine that must start at a slower rate. For seven speed-buildup methods see "Controlled Acceleration Devices," Mar 3, '58, p. 75.

Methods are also available that prevent overspeed conditions by employing a governing action. For details, see "Power Absorption Devices," Mid-Oct '57, p E13.

Updating the story on . . .



Silicone sponge is available in these two forms, molded and extruded.

SILICONE RUBBER SPONGE

Now, with better sponging grades, sharper process controls, and special reinforcing techniques—tolerances can be predicted and rejects decreased.

JAMES C. WALTON, *Pres., Chase-Walton Elastomers, Inc., Hudson, Mass.*

The right built-in chemical will blow rubber into sponge form, but for turning out precisely shaped parts this is like dealing with the wind—tolerance control is more difficult than when shaping a solid elastomer. However, recent developments in compounding and curing this sponge material make predictable tolerances a reality. Result is fewer rejects with an expensive material that has hard-to-find properties: resistance to prolonged high-temperature exposure, ozone, and vibration damage. To take advantage of these properties, however, design should follow the rules, reviewed here, based on behavior of the material during manufacture.

Whether molded or extruded, silicone sponge is made by adding a chemical blowing agent, similar to ordinary bicarbonate of soda, to the raw stock and expanding the mass to a closed-cell structure during the curing process. In molding, pressures are low because the cavity is only partially filled—so it's harder to control precise shape and tolerances than when molding solid rubbers where pressure is high. For extrusions, control is even touchier because expansion and complete curing occur after the rubber has left the die. Both sponge types have a smooth, noncellular skin because initial curing occurs against a smooth surface—either die or mold. Most sponge is molded sheet, where best tolerances can be held, though extrusion production is increasing and some progress is being made on molding intricate shapes.

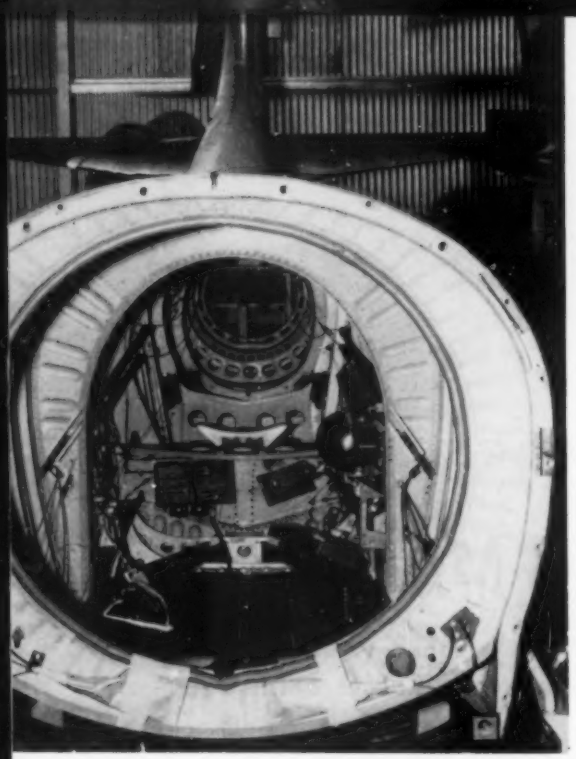
DESIGN PROBLEMS

Sponge products are designated "soft," "medium," or "firm," but the last two categories, compared in Table I, are most common. Overlap in pressure for 25% deflection in AMS standards shows that exact control over sponge properties is difficult to maintain. The following design practices pertain to both medium and firm sponge.

• **Size** of molded sheet can go to 24 in. square in thicknesses up to ½ in., and 12 in. square up to 1 in. thick. Max thickness is about 1¼ in. Slicing thick sheets will give thin ones, but preferred method is to mold the desired thickness directly, thus getting skin on both faces. For extrusions, min section thickness is 1/32 in. and max ratio of height-to-width on shape is 2.5. Length is not limited: extrusions up to 100 ft long are common.

• **Tolerances,** though now predictable on all sheet and most extrusions, will probably never approach those for solid rubber molding. Established sheet tolerances according to AMS standards appear in Table II, but extrusion tolerances are not as precisely defined. Limits for round rod bar, for example, range from 5% of dia at about ⅛ in. to 10% at 1¼ in. dia. A first approximation for the tolerance on the largest dimension of a symmetrical noncircular shape is to apply these figures to the circumscribing-circle dia, then set more precise tolerances by consultation with the fabricator. Where precise length is needed, reinforcing fibers of glass, cotton, rayon, Orlon or Dacron can be inserted without affecting compression characteristics of the extrusion. Organic inserts will lower top operating temperatures of the sponge. Cotton is limited to about 250 F, while synthetics will take 350 F.

• **Surface finish** is better on sheet, and parts cut from sheet, than on extrusions or parts sliced from them. This is because sheet is blown against mold surfaces—usually fabric-covered—whereas final sponging in an extrusion occurs against the unrestrained cured skin, leaving a



Firewall seal . . .

for Douglas A4D Skyhawk is Orlon-wrapped Dow Corning Silastic sponge, maintains positive seal between fore and aft sections of the aircraft.

Table I—Typical Silicone Sponge Properties

Property	Medium		Firm	
	AMS-3195[a]	SE-547[b]	AMS-3196[a]	SE-546[b]
Density, lb/cu in.	0.020 max	n.a.	0.030 max	n.a.
Temperature limits, °F	−100 to 400	−120 to 500	−100 to 400	−120 to 500
Compression for 25% deflection, psi	6–14	5–8	12–20	10–18
Compression-set after 22 hr at 212 F, % original deflection	60 max	55	60 max	60
Hardness[c], Shore A, ±5	n.a.	45	n.a.	45
Tensile strength[c], psi	n.a.	800	n.a.	800
Elongation[c], %	n.a.	250	n.a.	200

a—Aeronautical Material Specification No. n.a.—not applicable

b—Formulation of General Electric Co.

c—Measured on unfoamed stock

pebbly effect. There is considerable residual tension in the extrusion skin too—a good reason to avoid severe undercuts since these are often areas of additional stretching and possible rupture.

• **Abrasion resistance** of extrusion skin, normally poor, can be improved by wrapping the shape in glass or synthetic fabric either after the sponge is fully cured and expanded, or pre-formed so the sponge can be blown in place. In some cases, fabric forming and sponge extruding are done simultaneously. Fabric wrapping also facilitates fastening to metal and other surfaces. Adhesive fastening, normally difficult because silicones resist wetting unless special primers are applied, is simplified when fabric wrappers are used.

• **Small, close-tolerance parts** are more easily die-cut from molded sheet than sliced from extrusions. With the former, skin will be on the top and bottom surfaces; with the latter, it will be along the sides. This choice can be made when length of the part is 1½ in. or less—the max sheet thickness available—and is based on factors like the quantity involved, tolerances sought, and comparative cost of steel-rule cutting dies vs extrusion dies. Some distortion occurs in shaping.

• **Splicing** of extruded lengths is possible without weakening the sponge, but the required pressure results in some permanent distortion—a problem only where perfect appearance rather than performance is the main criterion. Spliced joints should be scarfed at an angle of about 30° with the load applied. Extra-long extrusions sometimes have to be built up from spliced sections if the extrusion must be laid down in a sharply curved pattern—in complex seals, for example.

• **Skin on all surfaces** is achieved through coating the open-cell edges of the sponged and cured part with room-temperature-vulcanizing silicone rubber—by dip, brush or spray application. Heavier skins are possible, but the process adds substantially to cost of parts.

Table II—Typical Sponge Sheet Tolerances

(From AMS-3195 and AMS-3196)

Dimension, in.		Tolerance, in. plus	minus
Nominal Thickness	1/16	1/64	1/64
	1/8, 3/16	1/32	1/32
	1/4, 5/16	3/64	1/32
	3/8, 1/2	3/64	3/64
Nominal Length and Width	6 and under	1/8	1/8
	over 6 to 18 incl.	1/4	1/4
	over 18	3/8	3/8

• **Sharp corners** and abrupt changes in cross-section are hard to get in both extrusions and moldings. Extrusions, because they are free-blown, always have slightly rounded corners. In molding sponge, the only force available to make the material take the mold shape is the slight pressure from decomposition of the blowing agent during cure. Solid silicone rubber parts are, on the other hand, molded under 500 to 1,000 psi and so can have clean lines and sharp corners.

• **Color** versatility usually associated with silicone rubbers is not available in sponge, though newer compounds can be tinted over the whole spectrum. Most common colors are white, brick red, tan, and green.

EDITOR'S NOTE: Other recent articles on elastomers include the following: "Faster Molding for Rubber Parts," June 23 '58 p 68, describes new process for economical precision parts; "Molded Silicone Rubber Parts," April 14 '58, p 69, defines limits of material and how to design parts; "High-temperature Butyl," Nov 11 '58, p 90, compares HTB with five similar elastomers; "Cast Urethane Rubber," Sept 16 '57, p 68, summarizes German experience with abrasion-resistant rubber now appearing in American products.

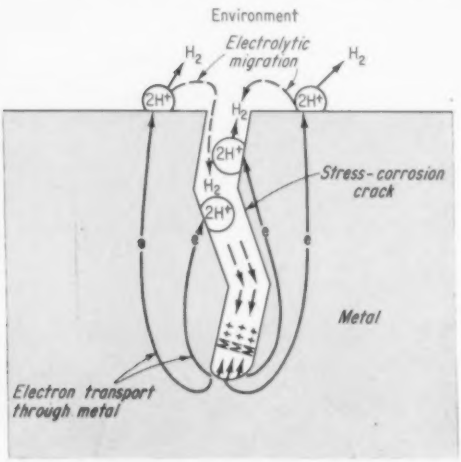
Residual stresses around stamped markings gave this display of fine cracks after corrosion.

watch out for . . .

STRESS CORROSION in METALS

Stress plus chemical environment can make it tough for some alloys to resist cracking. Here are the characteristics of this delayed-action damage, and some design steps to head it off.

DR. E. H. PHELPS, *Applied Research Laboratory*
United States Steel Corp.



WHY SUCH CRACKING—ONE ANSWER

The mechanism of stress-corrosion cracking is thought to be electrochemical in nature—resembling other localized attacks like pitting and ordinary intergranular corrosion. It works like a short-circuited battery. Once a fissure on the surface has been opened by applied stress, the tip of the fault serves as anode for the process (diagram above) while the external metal surface (and probably the sides of the crack as it propagates) acts as cathode.

Metal atoms at the tip of the fault, as in a pit, leave the atomic lattice and enter the corrosive environment as ions. Electrons flow from the anode, through the metal, to the cathodic area on the surface, and are released. Here, hydrogen ions, oxygen, or other such reducible material in the environment, accept the excess electrons. Return of electricity occurs in the solution by electrolytic conduction. Applied stress hastens the corrosion process by propagating the corroded fault and opening new areas to attack.

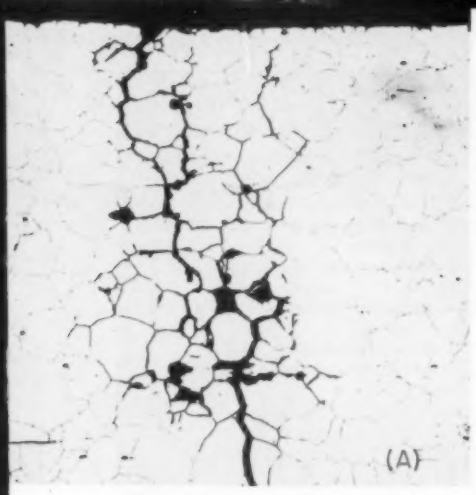
Only electrochemical theory explains electrochemical aspects of stress corrosion observed in lab tests. For example, cathodic-protection currents will prevent stress-corrosion cracks already in progress. Modifications in the theory have been proposed that involve a part-mechanical, part-electrochemical progression.

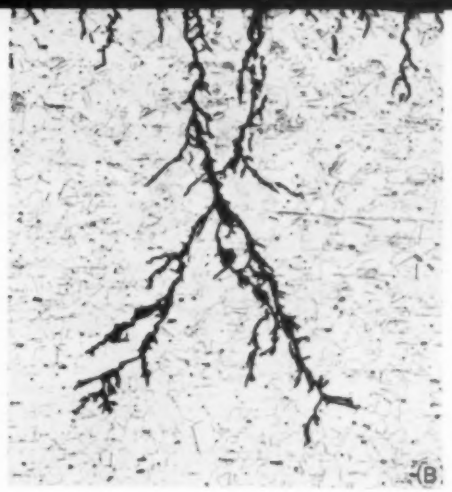
We still need a better way to predict just which environment will cause stress-corrosion cracks in a metal. One reason: the mechanism of this cracking is not completely understood. Another: it isn't easy to carry test data or experience from one application over to another. However, we do know enough about this corrosion to set up simple materials-selection and design procedures that will give longer lived products.

When stress plus corrosion causes more damage than corrosion alone—that's stress corrosion. It shows up as unexpectedly rapid cracking where tensile stress occurs. This cracking is usually accompanied by very little general corrosion, indicating the action here is something special. It is not to be confused with the damaging effects of general corrosion that can result in so much metal loss that remaining metal will not take the applied load.

Most metal systems have alloys susceptible to stress corrosion. Brass is a classic example. Others are iron, stainless steel, copper, aluminum, magnesium and lead. But only a few of the many diverse environments that engineering alloys are used in will cause the tell-tale cracking.

Of the three elements involved—stress level, chemical environment, and time of exposure—the first is simplest to manipulate in design. High tensile stresses, usually near the yield strength, must be present for stress-corrosion cracking in most cases. Working stresses, based on external loads, are less often the source of failure than internal stresses. This is because





Magnification shows paths . . .
of stress-corrosion cracking. Intergranular type (A) characterizes alloys that form boundary intermetallics upon heat treatment; here, austenitic stainless steel was purposely heat-treated to produce intergranular chromium carbide (X250). Transgranular attack (B) is less common, less understood. Lab specimen of austenitic stainless was cracked by high tensile stresses and exposure to boiling solution of 42% $MgCl_2$ (X100).

Ammonia vapors . . .
combined with residual forming stresses to crack this wrought brass fittings. Troublesome environments for other metals are tabulated on the next page.

the external loads used reflect the many safety factors employed in conservative design. The troublesome residual stresses can arise from many sources–forming operations, welding, press and shrink-fits, poor fit-up and fastening operations like riveting.

Chemical environment is important and can cause severe cracks. Ammonia vapor, for example, can be a bad actor where brass is concerned. However, for each such engineering metal susceptible to stress-corrosion cracking, there are, practically speaking, only a few chemical environments that need watching. The table on next page matches each main alloy system with the more common troublesome environments.

Time of exposure required for cracking is shorter at high stresses than at low stresses. Nonetheless, most such failures take considerable time to develop–years in some cases–and are often erroneously attributed to other causes. There is thought to be a "threshold stress" for some alloys and environments, similar to an endurance limit, below which cracking does not occur. But limits have not been well established here yet. In addition, simple aging effects in certain alloys, the high-Mg aluminum alloys for instance, can increase susceptibility to attack.

HOW CRACKS OCCUR

There are two types of stress-corrosion cracking, both explainable in most aspects by electrochemical theory:

Intergranular attack can occur with or without applied stress, but is accelerated by tensile stress. This attack penetrates through a corrosion-sensitive zone at the grain boundaries. For some alloys, this zone is well understood. For example, austenitic stainless steels with more than 0.03% carbon will, if heat-treated at 900-1200 F, precipitate chromium carbides at the grain boundaries–resulting in a chromium-depleted zone anodic to the carbides and the grains. A galvanic cell is thus formed in the metal, and intergranular corrosion occurs. This attack can be licked in design by specifying alloys with less than 0.03% carbon, or alloys stabilized with titanium or columbium–elements that immobilize the carbon by forming a harmless precipitate during heat treatment.

Aluminum-copper alloys are also sensitive to intergranular attack. Here, certain heat treatments will produce an aluminum-copper intermetallic compound in the grain boundaries. The copper-depleted zone, adjacent to the boundaries, is anodic. Again, rapid electrochemical attack occurs along the grain boundaries.

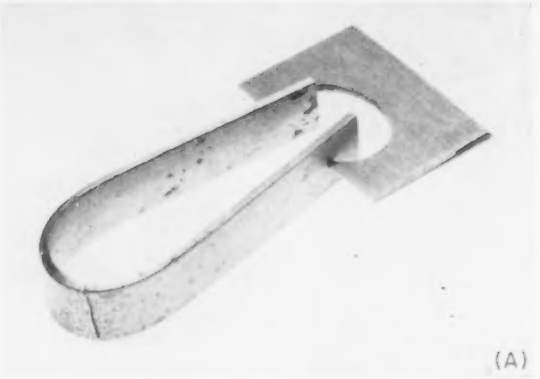
Transgranular stress corrosion is more puzzling. There is no apparent sensitive path for the crack to follow, yet characteristics of this attack resemble intergranular cracking so much it is probable that some type of path, as yet undetected, does exist. Outstanding characteristics are highly branched and twisting path through the metal, and multiple points of crack initiation. A word of caution, however: stress-corrosion cracks have been found where the path of propagation has been almost straight, with very little branching.

DESIGNING AGAINST STRESS CORROSION

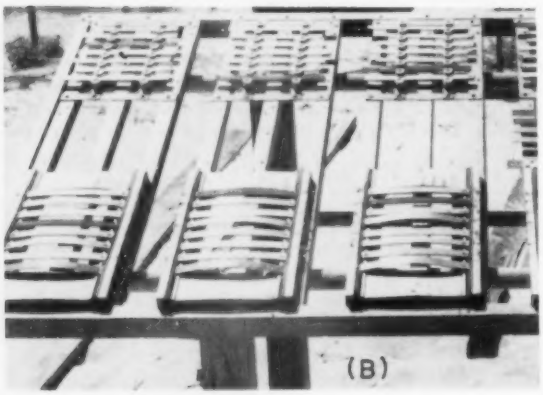
It is basic that good design practice from a general corrosion standpoint is an effective way to minimize stress-corrosion cracking. But what specific countermeasures can the designer follow? There are several:

• **Know your materials.** If one alloy is known to be susceptible to cracking in certain environments, and if an alternate alloy–resistant and economical–is available, then switch materials. But do some hedging: confirm the resistance of the new material by controlled testing and by reviewing prior service experience, if available. Some tests are simple, but in others the service conditions can be duplicated only by building a model. Such conditions as the splashing of cooling water in a heat exchanger–an action that leaves corrosion-accelerating deposits–can be reproduced only in this way.

• **Avoid built-in crevices** and conditions that can lead to pitting. Crevice and pitting corrosion are not im-



(A)



(B)

Two testing methods . . .
for alloy resistance to stress-corrosion cracking. Sharp U-bend (A) is quick, gross test; specimens in racks (B) are more precisely stressed (unloaded control specimens in background). Other procedures include loading with weights, springs or lever devices.

portantly affected by stress, but the environment within the crevice or pit is more acidic and concentrated than the bulk solution. Thus, a harmless bulk solution may be transformed into one that can cause stress-corrosion cracking. Where crevices are unavoidable, use paints, fillers, or insulating materials to keep the crevice free of the corrosive environment.

• **Watch outside surfaces of equipment** as well as inside. Wet insulation, in particular, can contribute to stress-corrosion attack through leaching of chemicals in the insulation. For example, failure of a heat exchanger made of austenitic stainless steel was traced to chloride-containing leachings from wet insulation. Recent tests on the effect of leachings from a number of commercial insulations showed stress corrosion could be produced in all cases.

• **Stress relieve** to get rid of residual stresses. Stress relief, properly performed, can be a powerful deterrent to stress corrosion. It is not a panacea, however, because it may cause too much distortion, or be inapplicable where mechanical fastening–like riveting or bolting–causes the condition. Success with this method usually depends on a well developed understanding of the sources of residual stress and, occasionally, the established methods of measuring it.

Alloys and Troublesome Environments

Alloy	Environments
Brass	Ammonia vapors and solutions; amines
Austenitic stainless steels	Concentrated chlorides; caustics
Aluminum-magnesium	Sodium chloride solutions; sea water
Steel	Nitrate solutions; caustics
Magnesium-aluminum	Chromate-inhibited chloride solutions

• **Avoid high thermal stresses in service.** This approach, unfortunately, runs counter to the current trend to higher operating temperatures for better efficiency–in engines and process equipment, for example. However, the designer has some control over three troublesome conditions: excessive rigidity in the structure, rate of heating or cooling, and frequency of the thermal cycle. Local-contact heat sources like strip heaters, for example, can generate very high thermal stresses.

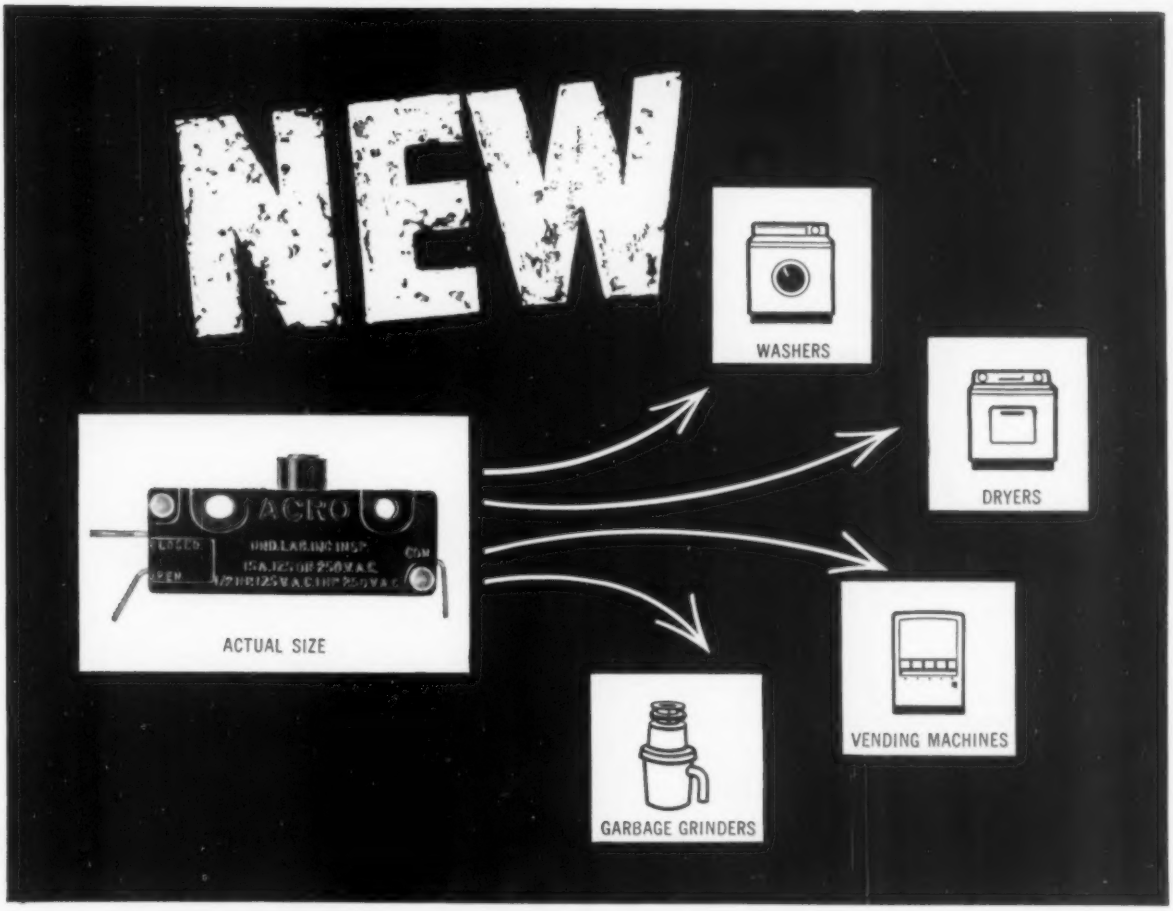
• **Control chemical environment.** Chloride and oxygen contents, for instance, are kept low in the primary systems of water-cooled nuclear power plants, to eliminate attack. But such preventive measures should be checked in controlled tests first, since a control that seems theoretically sound can make stress corrosion worse. Some corrosion inhibitors, for example, can reduce the time for cracking. Organic or metallic coatings, if nonporous and crack-free, can separate the metal from its environment and prevent attack, but should be tested before specification.

• **Consider shot peening or cathodic protection** in difficult applications. Even though the part is in tension, shot peening sets up a net compression stress on the exposed surface–a positive deterrent to stress corrosion which requires tensile stresses to get started. In cathodic protection, an impressed current from an external anode converts the entire exposed surface to a cathode, and stifles the dissolution reaction that normally occurs if the part is unprotected.

• **Avoid careless handling of work-hardenable metals.** Many stress-corrosion failures occur in supposedly annealed metal as a result of localized residual stresses set up from denting or crimping during transport, storage or assembly. This has often occurred in austenitic stainless steel heat-exchanger tubing.

• **Don't use cleaning agents heavily loaded** with chemicals known to increase susceptibility to stress corrosion. Dipping or pressure-spray cleaning techniques invariably leave residual solution on complex assemblies, and even small quantities can help corrosion take hold in service. For example, chlorinated organic solvents used on stainless steels hydrolyze in time to give hydrochloric acid–and its presence, even in small quantities, can easily initiate corrosion.

EDITOR'S NOTE: Recent articles covering in detail some of the problems raised in this artcle are: "Thermal Stress Fatigue," June '57, p 175 shows how high operating temperatures can accentuate premature failure; "Peening Cuts Stresses in Plated Parts," Dec 9 '57, p. 92—data shows how method prevents cracks, increases fatigue life of parts.



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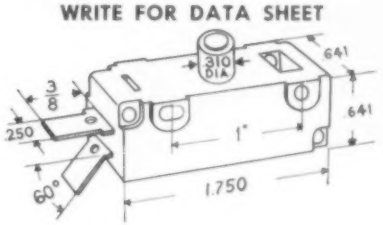

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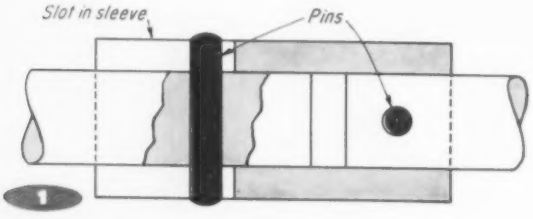
13 ways to COUPLE SHAFTS

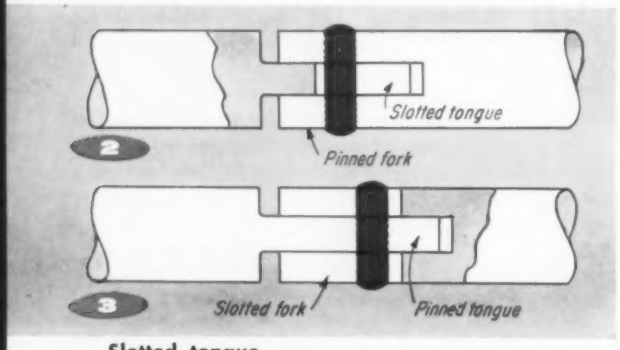
Included here are 8 methods allowing axial play, and 5 universal couplings giving angular play. In a coming issue Mr. Strasser will continue this up-to-date roundup with more coupling designs: based on pinned linkages and spherical shaft-ends.

AXIAL-PLAY COUPLINGS

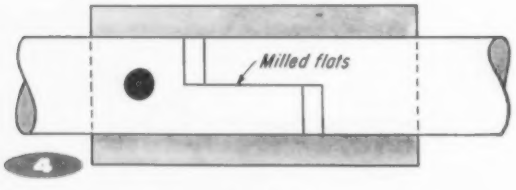
In-line movement of one shaft relative to another is often necessary, even though the shafts are perfectly aligned. Such axial play results, for example, when mounting tolerances are likely to cause large variation in distance between shaft ends. Also, in conditions of wide temperature variation, it is necessary to allow for shaft expansion. Two 8-ft aluminum shafts, for example, would have, for 100-F temperature variation, a combined axial expansion of nearly ½ in.



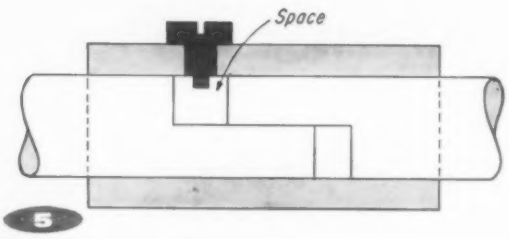
Sleeve is sliding fit . . .
over shafts. Shafts can be pinned, with one sleeve-end slotted; or sleeve pinned, with one shaft-end slotted.



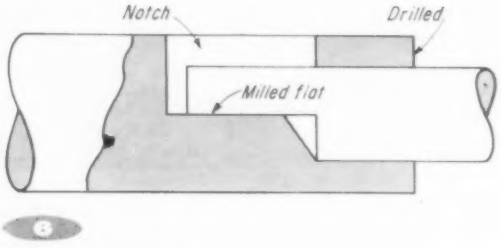
Slotted tongue . . .
and pinned fork (2) or pinned tongue and slotted fork (3) provide low-cost coupling.



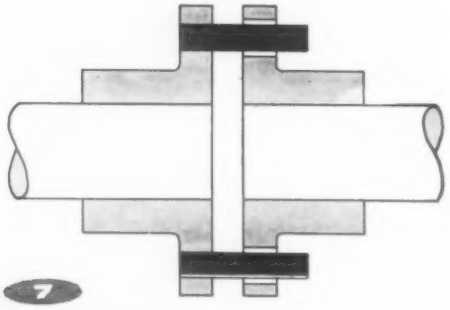
Sleeve fixed to one shaft . . .
while other shaft is free to slide in sleeve. Milled flats on shaft diameter provide for torque transmission.



Set screw prevents . . .
sleeve from sliding away from joint—space between shaft ends restricts sleeve movement.



Self-coupling shafts . . .
are possible when there is large difference in diameters. The larger shaft-end is drilled and notched to accommodate diameter of smaller shaft; the smaller shaft has half of its dia milled away.

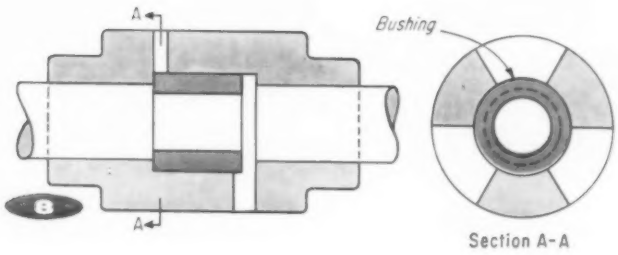


Pin-coupled flanges . . .
are preferable for high torques. Pins are inserted with a sliding fit in holes; flanges can be welded, press-fit, pinned, keyed or splined to shaft.

FEDERICO STRASSER
Mankewitz and Strasser, Ltd.
Santiago, Chile

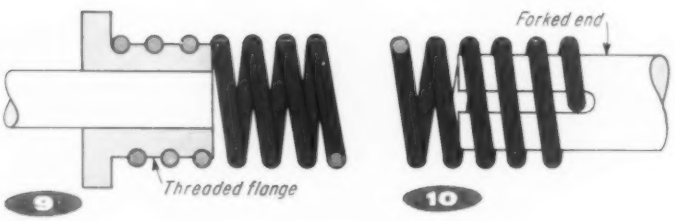
About the Author

Mr. Strasser received his higher education in Hungary and Italy before coming to Chile, where he is now partner in a firm that makes electrical and plastic products. He has been a frequent contributor of PRODUCT ENGINEERING Design Roundups that survey practical approaches to a problem. His versatile articles have been most welcome because our stepped-up publishing schedule requires 26 such Roundups a year—more than double the previous needs. The Editors are happy to receive ideas for Roundups and Reference Book Sheets from any reader who has material he thinks will be suitable.

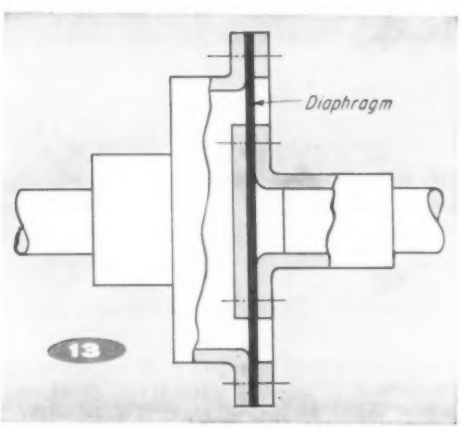


Jaw-type couplings . . .
are necessary for heavy-duty operation. Internal bushing ring keeps the two coupling halves in alignment.

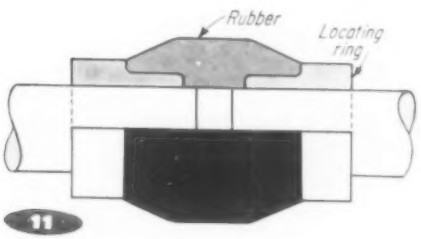
UNIVERSAL COUPLINGS

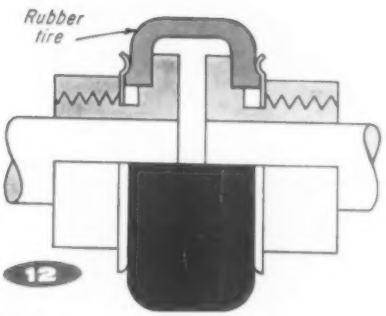


Inexpensive coupling . . .
is obtained by fastening a compression spring on either a threaded flange (9) or by introducing a forked shaft into the spring (10) so that the bent spring-end engages the fork.



Flexible diaphragm . . .
accommodates slight angular misalignment and also provides for axial movement of one shaft relative to another. It does not, however, take care of axial misalignment as do the preceding four examples.





Rubber sleeve . . .
mounted on locating rings (11) not only provides coupling, but also is effective vibration isolater. Rubber "tire" in more elaborate design (12) is replaceable because it is held by threaded collars.

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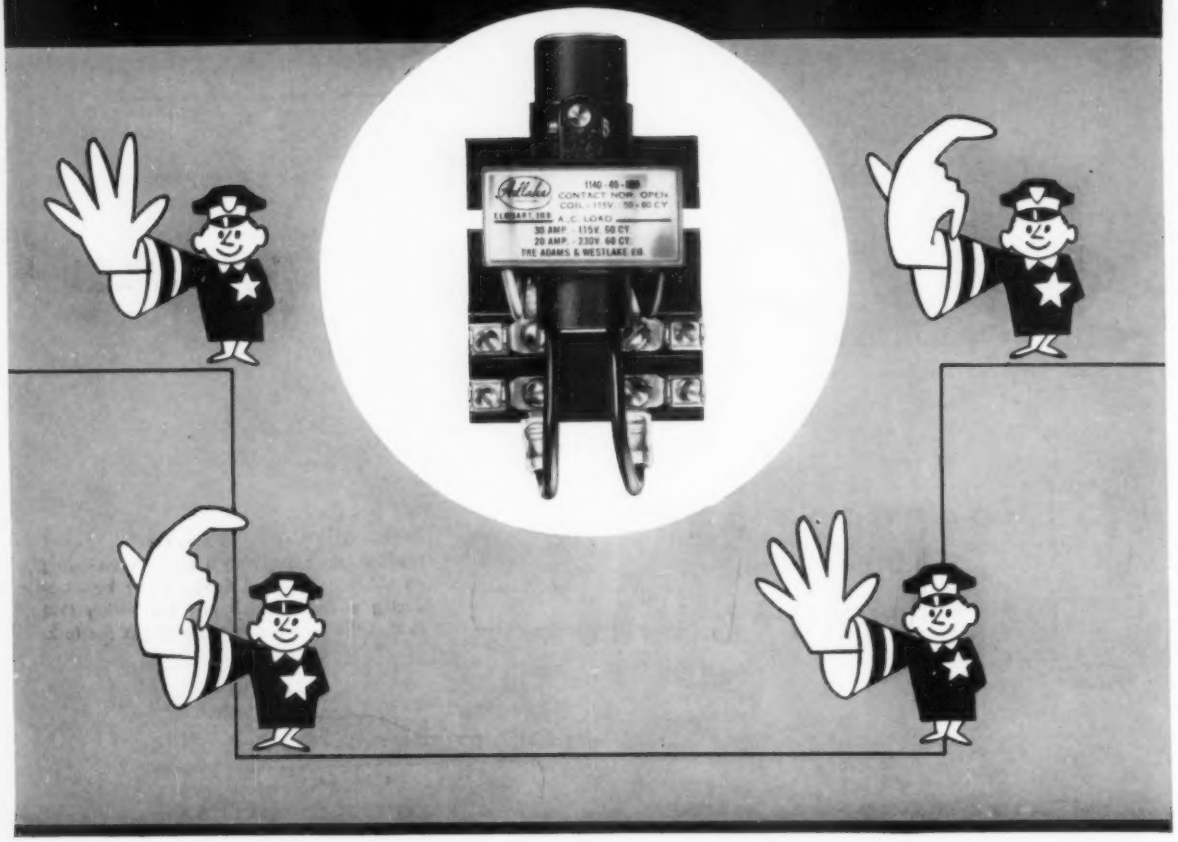

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How to figure deflections of . . .

Elastically Supported Cantilever Beams

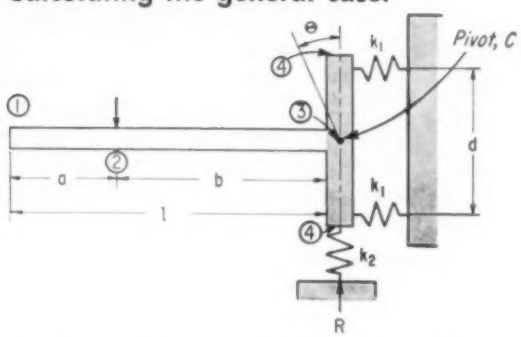
Formulas and diagrams for 8 BEAM MOUNTINGS.

T. F. CALLAHAN, *Research Div.*
United Shoe Machinery Corp., Beverly, Mass.

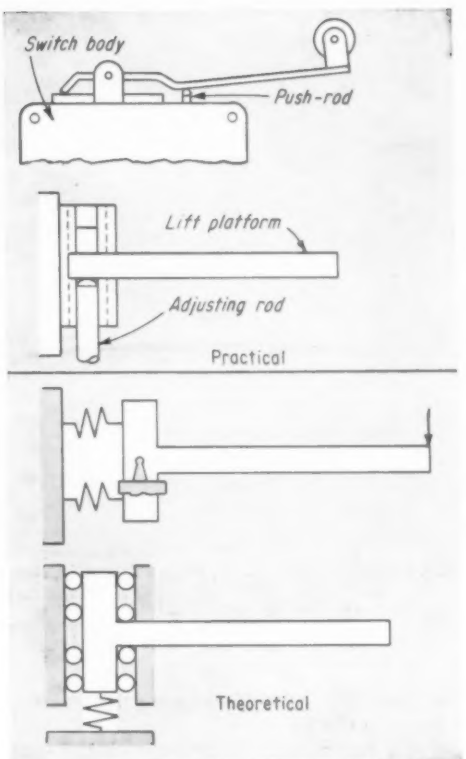
What are you going to do when a cantilever beam is not rigidly supported—how can you find its correct deflection under load? Here the support points themselves are yielding elastically—deflection becomes greater than the usual beam formula would indicate. This true deflection can be calculated from a formula that applies to the general case. Moreover, it can often be found easier by turning to the seven simplified cases listed here.

Knowing the true deflection pays off in improved design. In a cantilever-type punch press, for instance, quality of the cut depends on uniform penetration; if correct deflection is not allowed for in press design, poor operation will result. Another example: Many control switches are actuated by a cantilever-type flat spring pivoted in a fixed support and restrained by the contact-actuating push-rods. If correct beam deflection is not known, the switch may either shut off prematurely or not at all.

Calculating the general case.



It is assumed that horizontal motion of point 3 in above drawing is zero; deflection owing to shear is negligible; rotation of point 3 is small so that $\sin\theta = \tan\theta = \theta$; D_1, etc., is deflection at point 1, etc. The elastic coefficients, k_1, k_2, are elastic constants for the supports. They are found by dividing the load on the support by the support deflection. These k factors, however, are assumed known. All except one of the deflections are vertical.



Switch, and lift platform . . . are two practical examples of elastically mounted beams. Also shown above are the appropriate theoretical diagrams.

$$D_1 = \frac{P}{6EI}(2b^3 - 3ab^2 + a^3) + \frac{P}{k_2} + \frac{2Pb(b-a)}{k_1d^2}$$

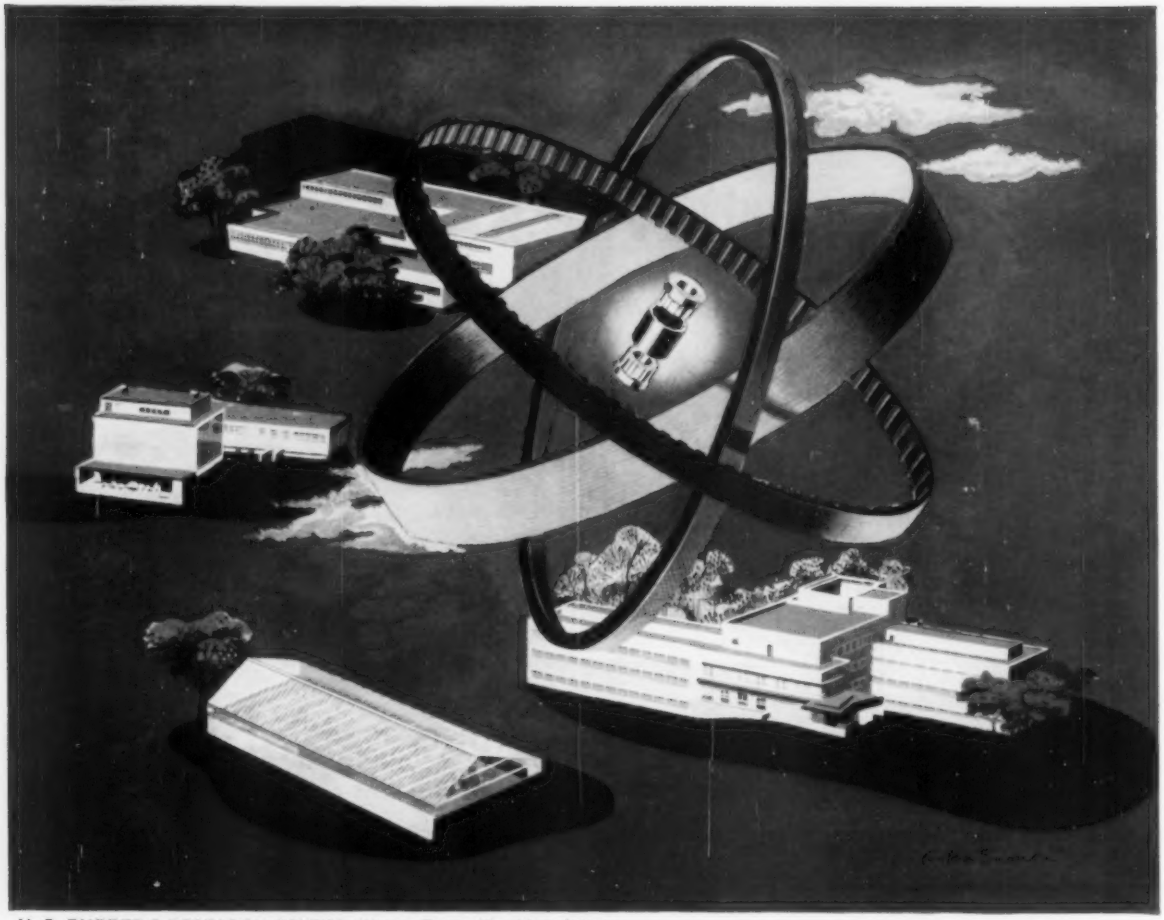
$$D_2 = \frac{P}{3EI}(b-a)^3 + \frac{P}{k_2} + \frac{2P(b-a)^2}{k_1d^2}$$

$$D_3 = \frac{P}{k_2} \qquad D_4 \text{ (horizontal)} = \frac{P(b-a)}{k_1d}$$

However, where the beam mounting can be repre-

(Continued on page 65)

US RUBBER TRANSMISSION BELTS



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Elastically Supported

CANTILEVER BEAMS (continued)

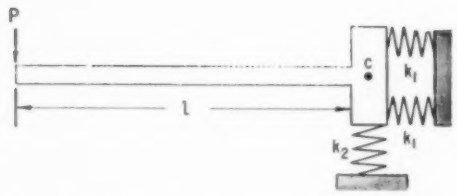
sented by some other arrangement of supports, the formula can be simplified because some of the expressions become greatly reduced.

For example, in case (5) since $k_1 = \infty$, and $a = 0$, the equation for D_1 becomes

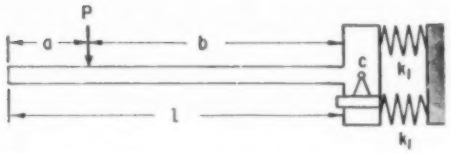
$$D_1 = \frac{Pb^2}{3EI} + \frac{P}{k_2}$$

Such simplification allows several cases to be tried quickly when it is not certain what mounting conditions really apply.

Seven beam mountings–with *k*-factor values that simplify the general case formula.

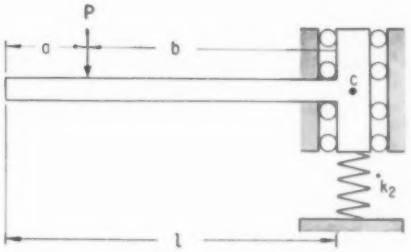


1. End load, yielding vertical support, yielding rotational support.
$A = 0$

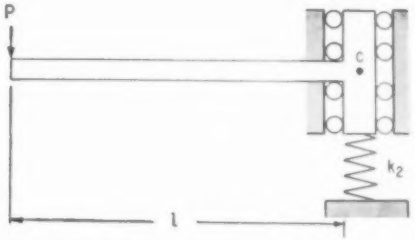


2. Intermediate load, rigid vertical support, yielding rotational support.
Let $k_2 = \infty$, $D_3 = 0$; a and b are arbitrary.

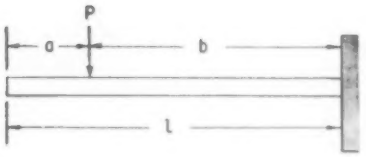
3. End load, rigid vertical support, yielding rotational support.
$k_2 = \infty$, $a = 0$, $b = b$, $D_3 = 0$



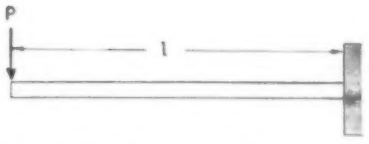
4. Intermediate load, yielding vertical support, restrained from rotation.
Let $k_1 = \infty$; a and b are arbitrary.



5. End load, yielding vertical support, restrained from rotation.
$k_1 = \infty$, $a = 0$, $b = b$
points 1 and 2 coincide

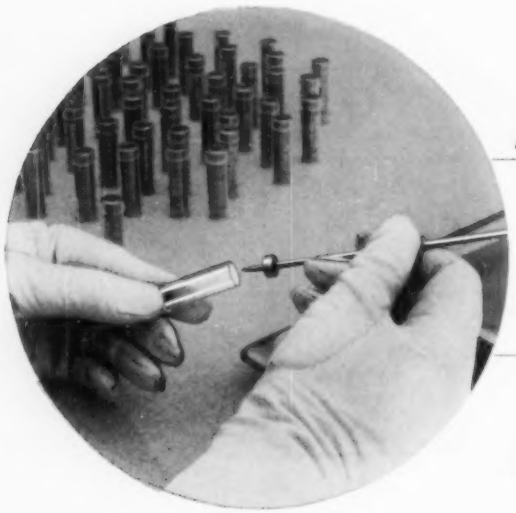


6. Intermediate load, rigid support.
$k_1 = k_2 = \infty$ $D_3 = 0$
a and b are arbitrary.



7. End load, rigid support.
Let $a = 0$, $b = b$
$k_1 = k_2 = \infty$, therefore $D_3 = 0$
and points 1 and 2 coincide.

WITH FAFNIR MINIATURE BALL BEARINGS YOU GET ALL FIVE IMPORTANT FEATURES



1

VACUUM MELT 440C. Balls and rings of Fafnir miniature bearings are made from vacuum melt 440C stainless steel.

ADVANTAGES. Since vacuum melt steel is extremely clean, balls and races are free from pits and inclusions providing better finishes which result in super sensitive bearings with low torque values.

2

BALANCED DESIGN. Each size bearing has its "tailormade" retainer of predetermined weight and dimensions.

ADVANTAGES. Pitch circle of the balls is centered between bore and O.D. and bearing is symmetrical in design.

3

HARDENED RETAINERS. All retainers are made of hardened 410 stainless steel.

ADVANTAGE. Precise hardening, insured against brittleness and easy breakage by quality control, provides springiness... eliminating bending or distortion.

4

SWAGED RETAINERS. In manufacture retainers are swaged so that ball pockets of retainers are ironed outwardly.

ADVANTAGE. Ball runs against a hardened, smooth surface not a rough edge.

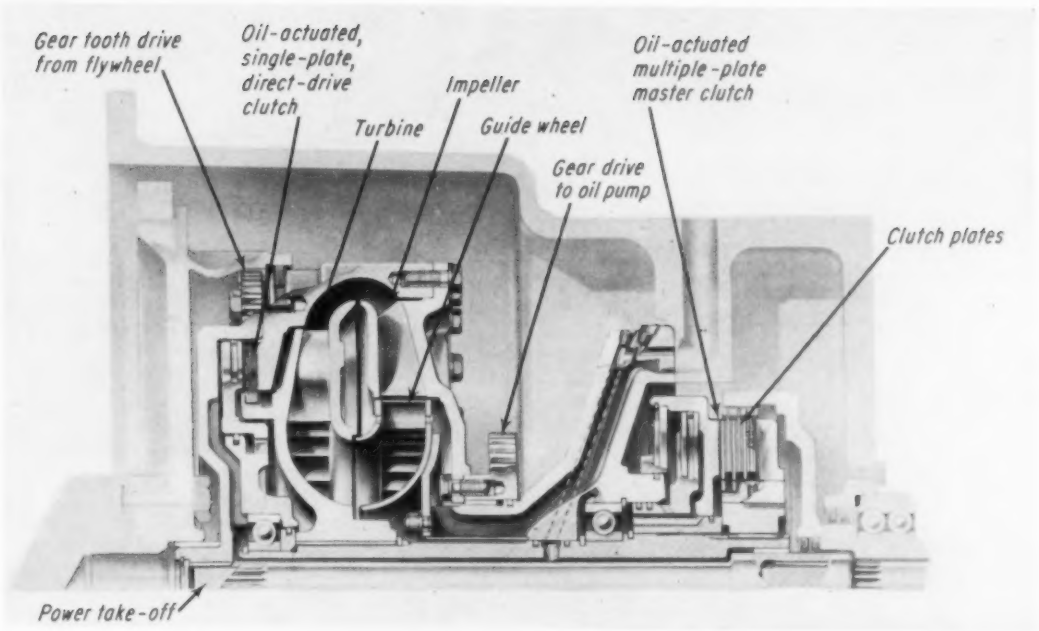
5

HEAT STABILIZATION. All rings and balls are heat stabilized to 600 degrees.

ADVANTAGE. Standard Fafnir bearings may be used for high temperature applications as well as regular applications.

All Fafnir miniature bearing tolerances are to ABEC-7 standards except for the inner ring bores where tolerances are +.0000 —.0002 to provide greater flexibility in selective assembly. Bearing balls are lapped to 2.5 millionths for sphericity and 5 millionths for size variation. Fafnir Miniature Ball Bearings are available in the following types: open; flanged; two shields and flanged two shields. Complete details and dimensions in bulletin No. 469. Write for copy. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
Most Complete Line in America



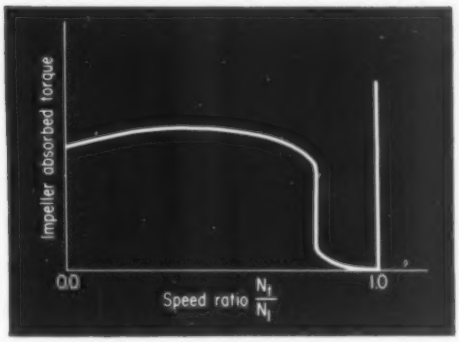
Torque Converter Built for Choice of Circuits

This single-stage torque converter, for heavy-duty earthmoving and industrial equipment, is available with either of two circuits, which provide different output characteristics. By purchasing a second–and different–pump, stator and turbine, converter can be changed from one circuit to the other.

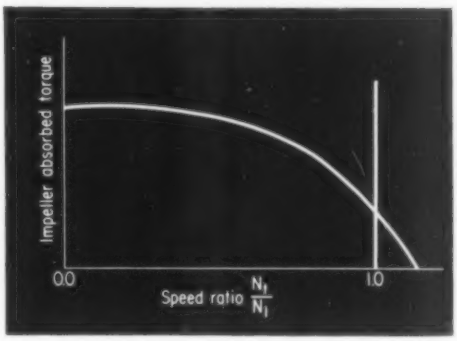
One of the circuits unloads engine with which converter is connected at approximately 0.825:1 speed ratio, thus tending to serve as its own output-shaft governor, and permitting impeller and turbine to remain clutched together even when stator is still in circuit. The other circuit provides 1.15:1 speed ratio; the higher absorbed torque at stall produces a moderately increased output-stall torque. The converter's clutches are said not to require adjustment and are released by basic circuit pressure, eliminating release springs.

The two circuits are available in four different sizes (roughly 11 to 18 in. dia) with a selection of five different impellers in each size. Depending on quantity ordered, size and required accessories, price is under $150. Delivery, 30 days. **Twin Disc Clutch Co., 1361 Racine St., Racine, Wis.**

Circle 1, inside back cover



High racing circuit



Unloading circuit

. . . CONTINUED ON PAGE 68

Mercury pushbutton switch . . .

mounts in any position and employs trapped pools of mercury which slide in and out of contact. Switch is SPDT break-before-make. Said to be especially adaptable to dry circuitry work. Switch has no contact bounce or chatter. Withstands 15-g shock and vibration with no displacement of mercury pools. Life is reported to be in excess of a million cycles. Switch case is 1 x ¾ in. dia. **Electrosonic Engineering Co., Inc., 2120 Pontius Ave., Los Angeles.**

Circle 2, inside back cover

Relay has no moving parts . . .

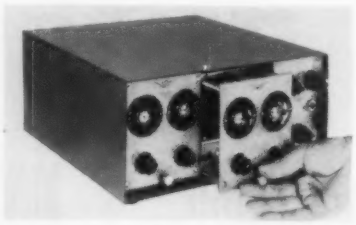
and will switch either ac or dc, has a transfer time of less than 50 microsec and is said to be free of contact bounce. Electronic coil circuit operates on 28 v dc, pulls in at 18 v and drops out at 7 v or less with a positive snap action. Coil circuit is completely isolated from electronic switching circuit, making one coil circuit capable of switching many independent circuits within one unit. Relay is completely potted and withstands shock and vibration. **Pendar, Inc., 2664 La Cienega Blvd., Los Angeles 34.**

Circle 3, inside back cover

Miniature air cylinders . . .

valves and fittings have standard ⅛-27 pipe threads. Design is adaptable to applications requiring trouble-free, high-cycle opening, closing, holding, ejecting, marking, centering, counting operations. The ⅜-in. bore, ½-in. stroke, single-acting spring return cylinder is machined from solid hexagon aluminum bar stock. Piston, ram and end cap are machined from cold-rolled steel. Cylinder permits replacement of packing. Three-way, normally closed valve for use with cylinders is fabricated as an assembly. Servicing valve does not require removal from line. Eight-port manifold permits multiple miniature cylinder actuations from a single source. **Air-Mite Devices, Inc., 4401 W. Kinzie St., Chicago.**

Circle 4, inside back cover



Modular electronic counters . . .

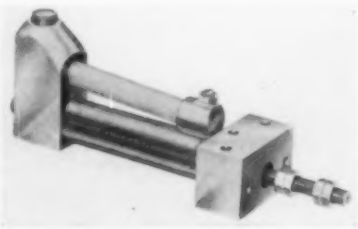
are standard in two to six digits, consisting of a plug-in amplifier and control unit plus any combination of two- and three-decade modules. Counting rate is 5000/sec max, accepting any standard waveform. Either ac or dc coupled inputs may be selected from front panel. Input pulse widths of 1 microsec provide adequate drive. Photocell input is provided. Depending upon number of decades used, operator may set any number from 1 to 999,999. Unit counts until the total is reached; then provides output pulse. **Erie Resistor Corp., 644 W. 12th St., Erie, Penna.**

Circle 5, inside back cover

Hydraulic power check . . .

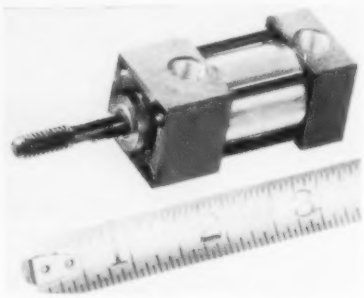
controls air-cylinder piston rods and reciprocating action, preventing chatter or shock and assuring uniform power feed. Consists of oil-filled checking cylinder, adjustable metering valve, and reservoir. Unit is installed by attaching mounting head to fixed base and piston rod to member to be controlled. As rod is pulled out, piston in checking cylinder forces oil through an adjustable metering valve and into reservoir and back to opposite end of checking cylinder. Oil flow through meter valve regulates speed of travel of piston rod that controls machine unit to which it is attached. Feed rate can be adjusted while unit is at work. Open system provides for instantaneous bleed-off of air that would otherwise be captured. **Burklyn Co., 3429 Glendale Blvd., Los Angeles.**

Circle 6, inside back cover

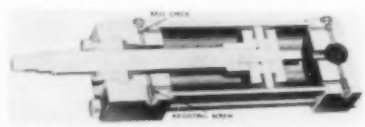


Small-bore cylinders . . .

for service to 2000 psi in accepted mounting styles are offered in sizes of ¾, 1 and 1½ in. One model, for 200-psi air or 750-psi hydraulic service, has brass tube with black oxide-treated steel heads, piston rod and tie rods. Another, for 2000-psi hydraulic use, has all black oxide-treated steel parts. Both series use replaceable O-rings for static and moving seals and are available for use with heat and nonflammable fluids. **Control-Line Equipment, 19560 Center Ridge Rd., Cleveland 16.**



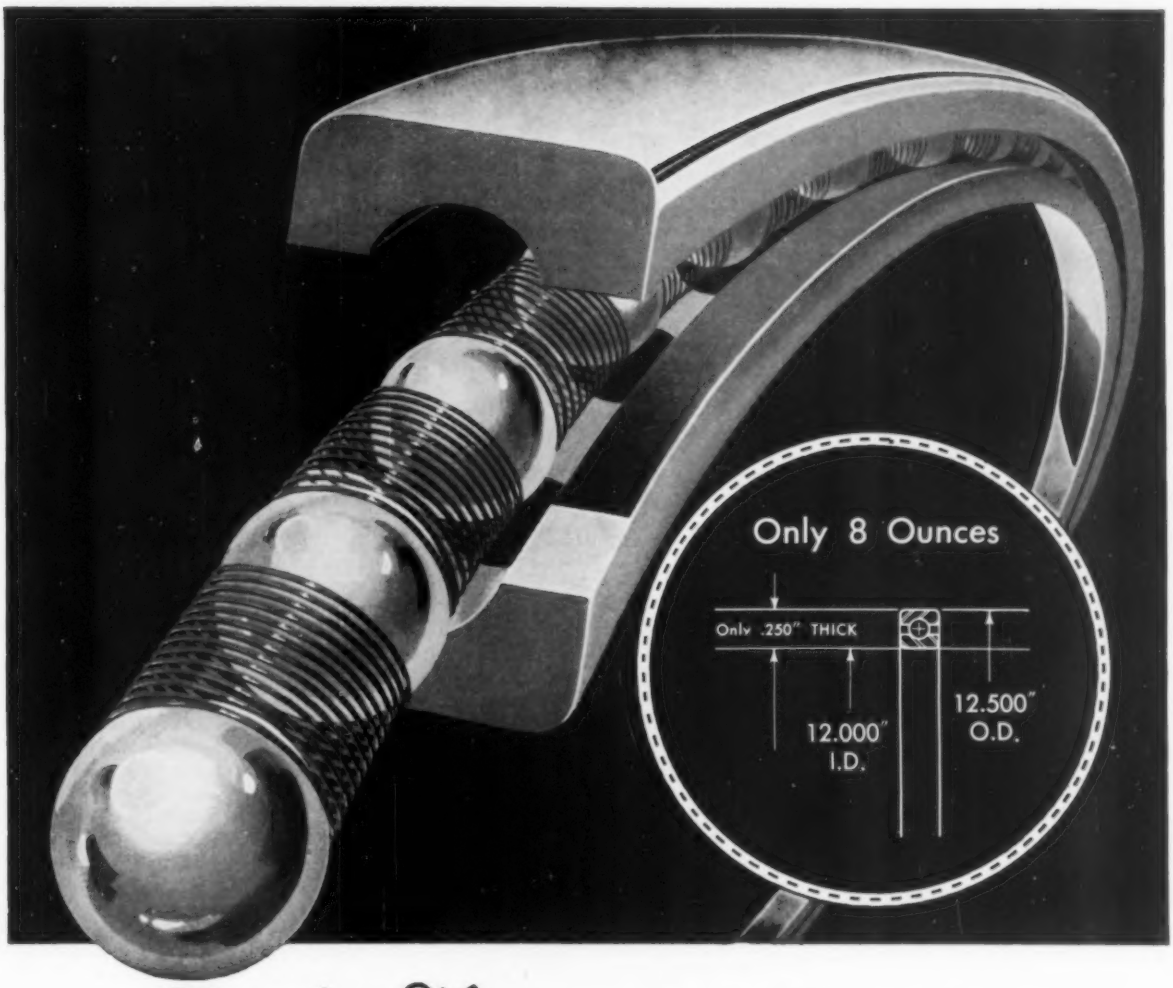
Circle 7, inside back cover



Self-locking adjustment . . .

for air cylinders is non-protruding, permitting the cushioned cylinder to be mounted even on the side containing the ball check or adjusting-screw assembly. There are no projections to break off or cause interference with machine com-

. . . CONTINUED ON PAGE 70



Reali-Slim... by Kaydon
world's thinnest radial ball bearing

HERE'S a typical example of Kaydon's *Reali-Slim* unique radial ball bearing that's finding wide application in practically every industry. *Reali-Slim* are the world's finest thin-section bearings and proportionately are thinner than a wedding ring. The bearing illustrated here is 12.000" I.D., 12.500" O.D., .250" thick — weighs less than 8 ounces. Designed for minimum weight and space limitations, it has a static load capacity of 5,520 lbs. and 894 lbs. at 100 rpm.

If you're looking for *Reali-Slim*, lightweight, radial ball or roller bearings, look at Kaydon's *Reali-Slim* line. Besides hundreds of standard *Reali-Slim* designs, there's a wide variety of special races, seals and separators to meet special bearing problems. What's more Kaydon is able to produce these *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual. In addition, Kaydon bearing engineers are prepared to give you valuable help with technical bearing application problems.

For complete data on *Reali-Slim* bearings for standard or special applications, ask for engineering Catalog No. 54RS-2.

***Reali-Slim* Ball Bearings** — in Conrad, angular contact, 4-point contact and other types are available in seven standard cross sections from .250" to 1" and in bore diameters from 4" to 40".

***Reali-Slim* Roller Bearings** — in radial or taper roller types are available in cross sections from 5/16" and in bore diameters from 5" to 40".

K-554

THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" bore to 178" outside diameter...
Taper Roller • Roller Thrust • Roller Radial • Ball Radial • Ball Thrust Bearings

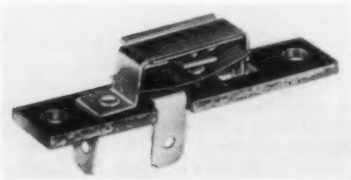
ponents. Adjusting screw and ball-check assemblies are also interchangeable in respective cavities. Adjusting-screw assembly can be moved into ball-check cavity to provide better access for cushion adjustment. Both ball-check and cushion-adjusting screw assemblies are permanently sealed against external leakage with Teflon seals impervious to most known gases, liquids, fluids and chemicals, and withstand temperatures from —100 to 450 F. **Miller Fluid Power Div., 2040 N. Hawthorne Ave., Melrose Park, Ill.**

Circle 8, inside back cover

Miniature hysteresis motor . . .

in ratings from 1/200 to 1/20 hp has heat rise of 68 to 100.4 F, depending on rating. Running torque ranges from 2.8 in.-oz to 28 in.-oz. Rpm can be selected by varying input frequency. Motor reaches full speed in 1 revolution and maintains synchronous speed at rated load. Adaptable to pull high-inertia loads. Totally enclosed. Configuration is the same, regardless of horsepower. Motor is 4⅛ in. dia x 3 5/16 in. thick. Weighs 4½ lb. **Dale Products, Inc., Box 136, Columbus, Nebr.**

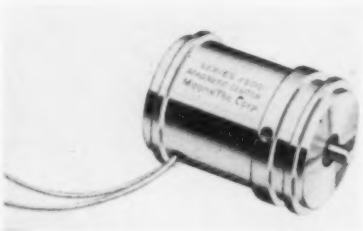
Circle 9, inside back cover



Flat snap-action switch . . .

has a flat actuator suited for pushbutton, cam or interlock applications on business machines, remote controls. Built-in positive stop limits overtravel and prevents damage to snap-action switch mechanism. Over-center bowed blade provides high contact pressures and fast contact transfer. Variations of operating point and force are possible by changing the point of operation on wide actuator. Rated 10 amp at 125v ac; 5 amp at 250v ac and ½ hp at 125 to 250v ac. Panel measures 2¼ x ½ in. and switch mechanism extends ⅜ in. above panel base. Normally open switches are 17.2¢ each in 10,000 unit quantities. **Cherry Electrical Products Corp., 1650 Deerfield Rd., Highland Park, Ill.**

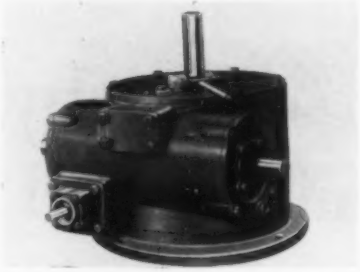
Circle 10, inside back cover



Miniature magnetic clutches . . .

are available in double-ended models with servo- or flange-mounting surfaces. Fast response and torque values to 100 in.-oz with zero torque in completely disengaged position are provided. Engagement can be accomplished without axial movement of input or output shaft. Adaptable to high vibration and shock conditions. In ½ to 3-in.-dia sizes. **MagneTec Corp., 11785 Olympic Blvd., Los Angeles 64.**

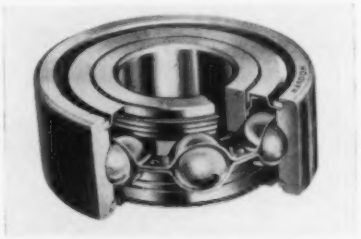
Circle 11, inside back cover



Cam-operated indexing unit . . .

for positioning between automatic production stations operates with index shaft vertical or horizontal. Dial plates and tooling plates can be furnished and attached. Each revolution of cam shaft rotates dial plate or index shaft one station. As many as 8, 12, 16 or 20 indexings can be obtained during one turret cycle. Versatility has been increased by offering cams in a choice of ratios between work and dwell time. Work time can be either ¼, ½ or ¾ of each index cycle. Unit can be supplied with or without an integral 20:1 or 40:1 speed reducer on input shaft. Cam-shaft extensions provide means for operating production drives or auxiliary drives. Accuracy of all motion is maintained by cams and tapered bearing. **Standard Tool & Mfg. Co., 237 Laurel Ave., Kearny, N. J.**

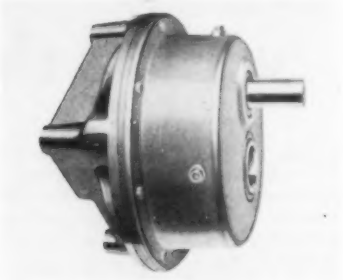
Circle 12, inside back cover



Self-lubricating bearings . . .

have dual-labyrinth seals that hold lubricant and employ slinger action to circulate lubricant. Designed to standard double-row bearing widths, cartridge bearings have extra-large reservoirs. Dual-labyrinth seals, which lock in lubricant, are formed by an inner and outer shield, fitted to create a horizontal and vertical labyrinth. Inner shield, rotating with inner raceway of bearing, provides centrifugal force that slings or returns lubricant to working surfaces. Bearings feature high load capacities, quiet operation; carry radial or thrust loads in either direction. Rated radial load capacities are from 2063 psi at 50 rpm to 394 psi at 7200 rmp; from 18420 psi at 50 rpm to 3514 at 7200 rpm for range of bearing sizes. Bore and OD are same as standard single row bearings. **Hoover Ball and Bearing Co., Ann Arbor, Mich.**

Circle 13, inside back cover



Flange-mounted drive . . .

bolts directly to driven machine. Designed with bearing capacities for overhung and thrust loads for installation into driven machine as a geared pillow block, if desired. Built to AGMA recommendations. For horizontal or vertical applications, with high-speed shaft up or down. Furnished from stock in single reduction units for ½ to 10 hp applications; in two double

. . . CONTINUED ON PAGE 72

Prongs snap into punched or drilled hole

CUSTOM-DESIGNED AND MASS PRODUCED TO YOUR PARTICULAR REQUIREMENTS

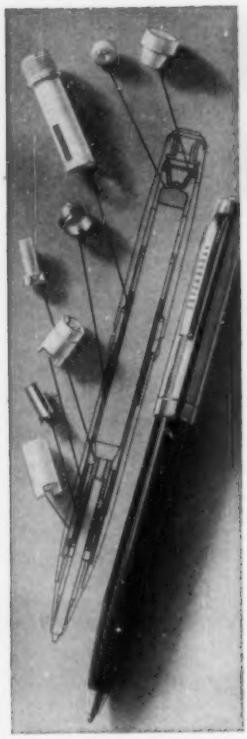
Dot plug buttons were originally used in automobiles to fill spaces on standard models which, on de luxe models would be occupied by such extras as cigarette lighters, radio controls and so on. They are now also widely used as lenses for indicator lights and as identification buttons on instrument and control panels of all kinds.

Available in clear or colored plastics... brass or steel in all standard finishes... embossed and enamel-filled or molded to show company insignia or other identification symbols . . . Dot plug buttons snap into place and stay where they're put even under conditions of extreme vibration. Yet they can be removed and replaced repeatedly without damage.

CARR FASTENER COMPANY

DIVISION OF UNITED-CARR FASTENER CORPORATION 31 Ames Street, Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS



MATED PARTS HELP NEW PEN

8 tiny parts die cast and molded by GRC for Esterbrook . . . precision "mated" to solve the intricate parts problem posed by new-type ballpoint pen

GRC molded 6 tiny parts in nylon and die cast 2 in zinc alloy to form the foundation of the new rotating mechanism evolved by Esterbrook engineers. The uniformity and accuracy of GRC's unique automatic single cavity die casting and molding methods made possible the precision mating of tiny parts...eliminated the necessity of selective assembly...assured trouble-free operation of the assembled pen...and again provided a new dimension to designers faced with a difficult situation.

NO SIZE TOO SMALL! Maximum size: Zinc Alloy ½ oz. 1¾", Plastic .03 oz. 1¼".

Write for detailed bulletins or send prints for quotation. Quick deliveries on quantities of 25,000 to millions.

World's Foremost Producer of Small Die Castings

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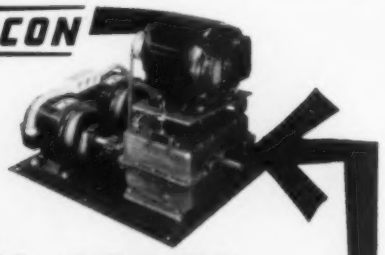
CIRCLE 127 READER SERVICE CARD

SPECON

FULLY REVERSING ELECTRICAL DIFFERENTIAL DRIVES



Full Rating, Full Torque at Zero Speeds • Fast Response • Low Drive Inertia • Zero Backlash

Electrical Differential Drives are part of the family of SPECON variable speed drives and differential transmissions designed and produced by Stratos. They utilize a motor-generator combination electrically coupled in a closed loop and mechanically coupled to a double differential gear box.

The entire output range, from 0 to max. r.p.m. is accomplished by operating the two DC machines at a maximum variation of 2:1.

These drives are suited for installations requiring fully reversing feature (EDD type) and for winding applications where a large build-up occurs (EDW type). For complete information, (including capacity charts and output speed regulation), on Electrical Drives, Mechanical Differential Transmissions, and Gear Boxes, write to:

SPECON Stratos Industrial Products Branch #42, Route 109, West Babylon, N.Y.

Turbo-Expanders and Compressors • Pneumatic Pressure Regulators • SPECON Variable Speed Drives and Transmissions

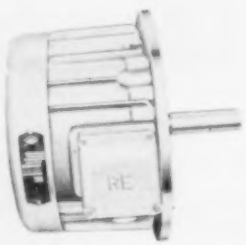
reduction ratios for ½ to 5 hp. Constructed with precision helical gears. **Falk Corp., Dept. 255, 3001 W. Canal St., Milwaukee 1.**

Circle 14, inside back cover

Vinyl-to-metal laminate . . .

is fused by extreme heat and pressure. Color and surface embossing are said to be very stable and material is reported highly resistant to abrasion, impact and staining. Vinyl does not affect basic fabricating properties of base metal (chemically treated steel or aluminum). It may be deep-drawn, bent, punched, roll-formed, crimped with standard production techniques without separation of laminate or damage to surface. Available in sheets to 32 x 144 in.; coils up to 32 in. wide and in all popular gages and tempers; a wide range of vinyl color, texture and thickness. **American Nickeloid Co., Peru, Ill.**

Circle 15, inside back cover



Machine tool motors . . .

in ratings from ½ through 10 hp feature a fin-type design that, in conjunction with high-heat conducting and cast aluminum alloy frame, provides heat-dissipation ratio said to be approximately three times as efficient as cast iron. Heavy-duty units have vibrationless running characteristics and wafer-thin compactness found in smaller motors. Rotors are dynamically balanced and mounted between two heavy-duty ball bearings. Close tolerances are said to be maintained. Radial airgap design permits use of light, thin, low-inertia rotor, which, in turn, permits smooth starts and quick stops. Offered in totally enclosed fan-cooled and non-ventilated types for continuous or intermittent duty. **Reuland Electric Co., Alhambra, Calif.**

Circle 16, inside back cover

Electronic relay . . .

is used in conjunction with photoelectric scanning heads within 25000 ohm to 1½ megohm resistance range for such applications as monitoring, filling, counting, detecting, registration and inspection. Re-

(Continued on page 76)

"WEIRZIN'S ZINC-COATED SURFACE DEFIES CORROSION—TAKES PAINT BEAUTIFULLY!"

REPORTS LINCOLN METAL PRODUCTS CORPORATION, MAKERS OF BEAUTYWARE

A leading manufacturer of such housewares as kitchen canister sets, bread boxes, step-on cans and towel dispensers, Lincoln Metal Products of Brooklyn, N. Y., finds Weirzin electrolytic zinc-coated steel a natural for its purposes.

"Inventory problems are simply non-existent," says a spokesman. "You can store stamped-out parts of Weirzin indefinitely—even for years without worrying." Because its electrolytically fused zinc coating is so tight, not even the severest bending, drawing or crimping operation will flake or peel off its surface during fabrication. No exposed steel—no corrosion problem!

Also you'll discover—as have Lincoln Metal Products and many other users—that appearance is not the only beauty of chemically treated Weirzin's paintability: the economy of that lasting paint job is one of its biggest drawing cards, too.

In the market for a metal that combines strength, economy and super-resistance to corrosion? You'll find it eminently worth your while to investigate Weirzin.

Free Booklet "Weirzin" Gives Complete Details. Write to Weirton Steel Company, Dept. D-19 Weirton, West Virginia

WEIRTON STEEL COMPANY

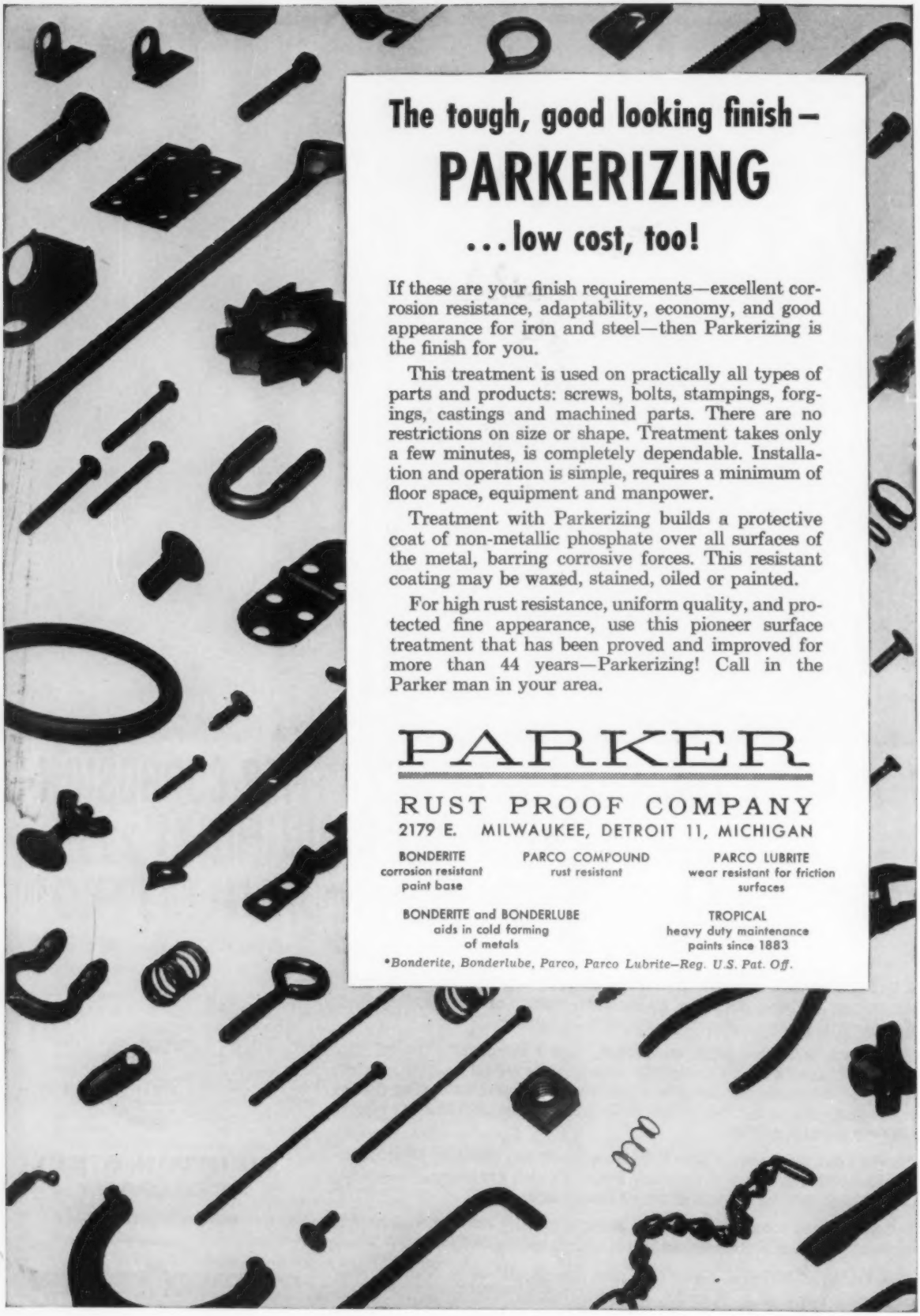
WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

CIRCLE 129 READER SERVICE CARD



The tough, good looking finish—

PARKERIZING

...low cost, too!

If these are your finish requirements—excellent corrosion resistance, adaptability, economy, and good appearance for iron and steel—then Parkerizing is the finish for you.

This treatment is used on practically all types of parts and products: screws, bolts, stampings, forgings, castings and machined parts. There are no restrictions on size or shape. Treatment takes only a few minutes, is completely dependable. Installation and operation is simple, requires a minimum of floor space, equipment and manpower.

Treatment with Parkerizing builds a protective coat of non-metallic phosphate over all surfaces of the metal, barring corrosive forces. This resistant coating may be waxed, stained, oiled or painted.

For high rust resistance, uniform quality, and protected fine appearance, use this pioneer surface treatment that has been proved and improved for more than 44 years—Parkerizing! Call in the Parker man in your area.

PARKER

RUST PROOF COMPANY

2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE
corrosion resistant paint base

PARCO COMPOUND
rust resistant

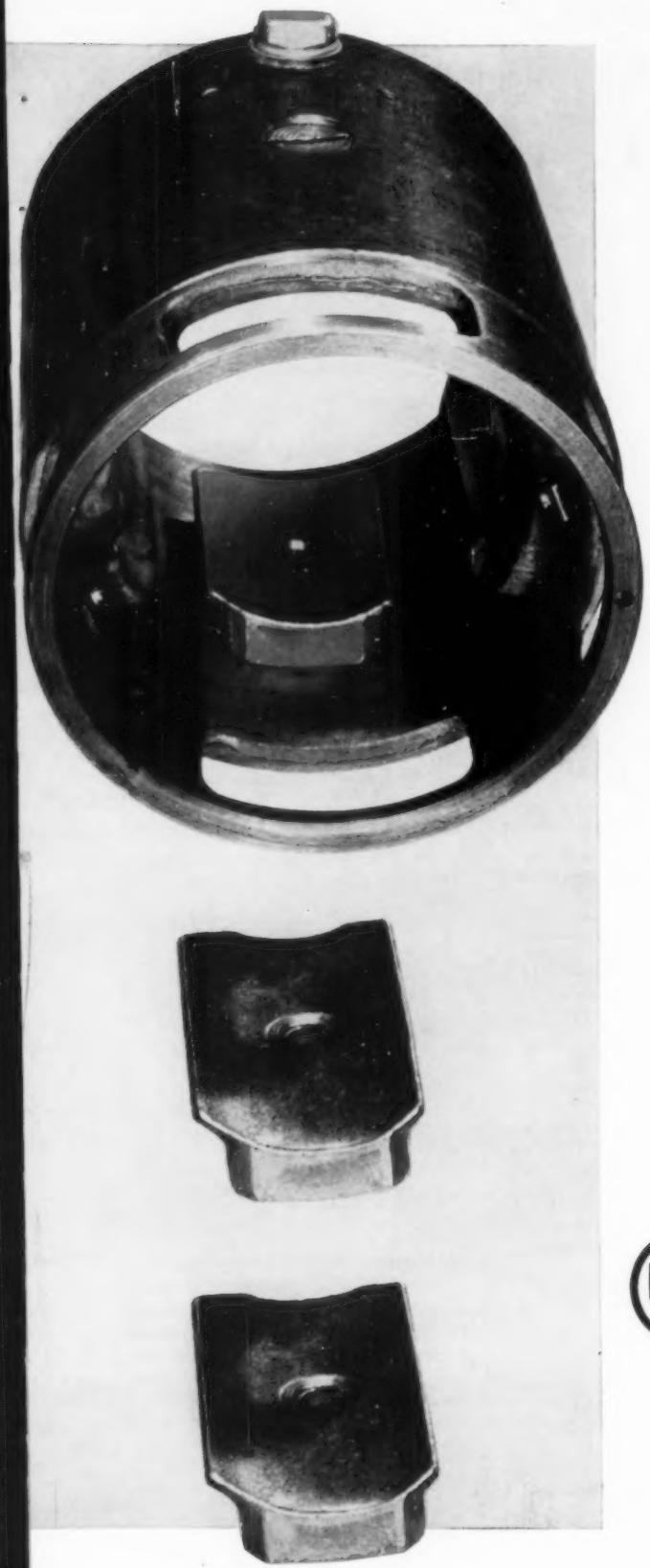
PARCO LUBRITE
wear resistant for friction surfaces

BONDERITE and BONDERLUBE
aids in cold forming of metals

TROPICAL
heavy duty maintenance paints since 1883

Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



Auto starter pole shoes by the thousands—

made from steel already rolled to shape!

An automobile parts manufacturer produces thousands of automobile starter motors daily. Each one takes four pole shoes. To machine these parts from rectangular bars or to use built-up laminations was too slow and too costly.

They solved the problem by making the pole shoe from USS Special Section Rolled Steel Bars. The cross section of the bar is rolled so close to that of the pole shoe that no machining is required. They merely shear the shoe to length, punch the mounting hole, clean and tumble, coin to obtain precise curvature, and tap the hole.

These operations are set up on a mass-production basis and pole shoes come tumbling out at a rate of 11,000 per day, or more. There's very little scrap and unit costs have been reduced to a minimum.

Why not find out what USS Special Sections can do for you? For more information, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

A better product at lower cost when pole shoes are manufactured from USS Special Section Bars.

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

USS

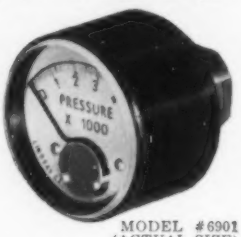
United States Steel

New high pressure gauge passes 25 G "torture test" with ease

This photograph shows vibration testing of RMC-Lindsay gauges on the 3200 force pounds Calidyne Vibrator—1 to 25 G output, amplitude .0001 to .20, cycling frequencies to 2,000 cps. Pressurizing and testing are uniquely accomplished so as to parallel actual installation conditions. Complete test reports are available on request.

RMC-LINDSAY GAUGE

already checked out in Atlas missile and B-52



MODEL #6901
(ACTUAL SIZE)

The Atlas ICBM and B-52 bomber are two of the newer space age vehicles to use the RMC-Lindsay high pressure gauge. In both laboratory test and actual use, this gauge has met all requirements with room to spare.

The RMC-Lindsay Gauge is a multiple-coil, helical bourdon tube type, restricted for over-pressure. The pointer is attached directly to the end of the coil, eliminating the use of linkages and pivots.

The helical bourdon element is, of course, not a new development. However, the RMC-Lindsay techniques in coiling, heat treatment, calibration and material specifications *are* new—and exclusive with RMC.

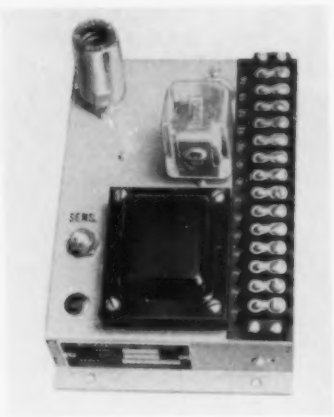
PRESSURE RANGE: Pressures in ranges 0 to 1,000 p.s.i. up to 15,000 p.s.i. with retard scales available. *OVERLOAD PRESSURE:* Nominal overload pressure factor of 2.0 times the maximum dial reading (higher factors available). *BURST PRESSURE:* Normally 3.0 times the maximum dial reading. TEMPERATURE: Not affected by temperatures up to 250°F. *VIBRATION:* Qualification test report available on pressure tests showing cycling, vibration, from 0 to 2000 cps. at 25 G's, and resonant frequency vibration tests at 25 G's. *SHOCK:* Data available on MIL-E-5272A shock test at 40 G's (satisfactorily drop tested up to 900 G's in special tests). *PULSATION:* Practically unaffected by line pulsations of 3% of the full dial reading. *ENDURANCE:* 10,000 cycles up to 250,000 cycles, depending on application. *ACCURACY:* Hysteresis friction and backlash are below readable limits. Absolute gauge accuracy to 1½% average, 1% when requested.

Whatever your high pressure gauge problems may be, why not let RMC engineering skill provide the answers. Write to either of the addresses below.

ROCHESTER MFG. CO. OF CALIFORNIA
97 Beacon Place, Pasadena, California

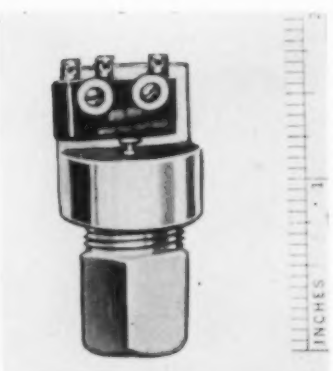
ROCHESTER MANUFACTURING CO., INC.
214-C Rockwood Street, Rochester 10, N. Y.

RMC
LINDSAY PRESSURE GAUGES



lay and scanners respond to light changes: darker or lighter, direct or reflected beam. Small signal changes are amplified electronically through a vacuum tube. At 6 in. between scanning heads, over 2000 beam interruptions/min can be counted. Relay can also be used with variable-resistance transducers, electronically amplifying low-energy signals. Unit is composed of enclosed plug-in relay, potentiometer, power supply for external light source and circuitry. Power consumption is 9w; power source, 100 to 130v, 50 to 60 cps. Relay contacts are DPDT, 8 amp at 115v ac, noninductive. Can be furnished in a NEMA No. 1 housing or chassis alone. **Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.**

Circle 17, inside back cover



Miniature pressure switch . . .

is 1$\frac{53}{64}$ in. long x $\frac{13}{16}$ in. dia and will operate from 25 to 1000 psi with an over-pressure rating up to 3000 psi. Operating pressure is factory-set. Switch withstands max pressure without damage or affecting subsequent operation. Piston-type switch is anodized aluminum with a single moving part. Incorporates UL-approved switch, 5 amp, 240v ac. Electrical contacts are SPDT. Switch has $\frac{1}{4}$-in. NPT inlet open-

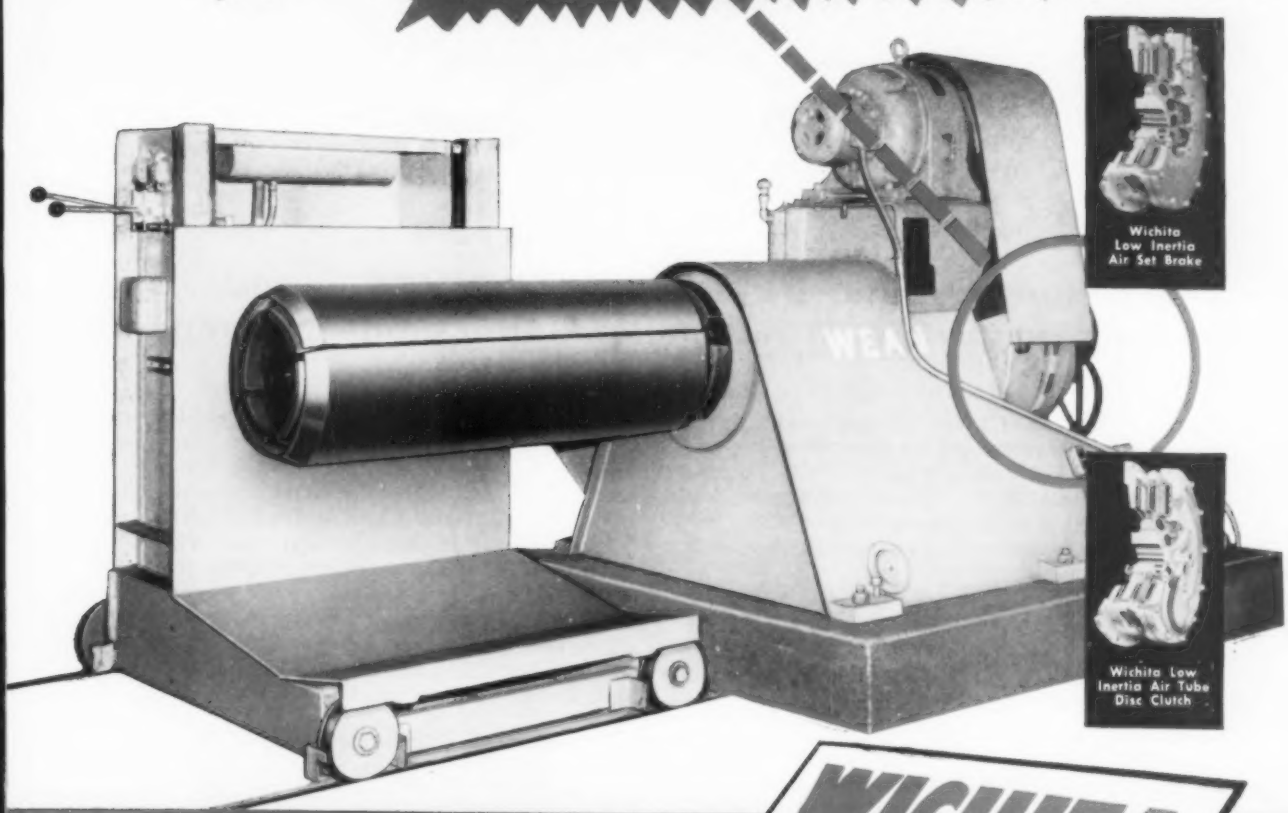
(Continued on page 80)

WEAN has standardized on WICHITA BRAKES for this uncoiler

"The illustration shows one of our 52" overhung mandrel uncoilers which is equipped with a Wichita Air Brake," says engineer Krepp of the Wean Equipment Corporation. "We have standardized on Wichita Brakes for this class of uncoiler because of better design, trouble-free operation and performance. We have found that Wichita Brakes give us considerable leeway on size." For peak performance in clutches and brakes on any equipment it will pay you to standardize on Wichita . . . contact your nearest Wichita engineer today!

"Better Design... Trouble-Free Operation... and Performance,"

says J. D. Krepp, Wean Senior Staff Engineer



Wichita Low Inertia Air Set Brake

Wichita Low Inertia Air Tube Disc Clutch

Contact your nearest Wichita Engineer!

Brehm-Lahner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yorline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
W. G. Ballantyne Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Now STATIC POWER Adjustable Speed Packaged Drives

No moving parts...

Cutler-Hammer *ULTRAFLEX®* *DRIVES* provide outstanding savings in installation—operation—maintenance

No moving parts! Light, compact static power conversion units have replaced the conventional m-g set. Ultraflex Packaged Drives save up to 50% in valuable floor area . . . up to 75% in weight, permitting rapid, low cost installation or rearrangement of production machinery without special handling equipment or floor loading preparations.

No moving parts! Ultraflex Packaged Drives provide a new high standard of operational efficiency and ultra-responsive speed control. Works perfectly without forced ventilation . . . less power wasted as unwanted heat. No power robbing friction or windage losses.

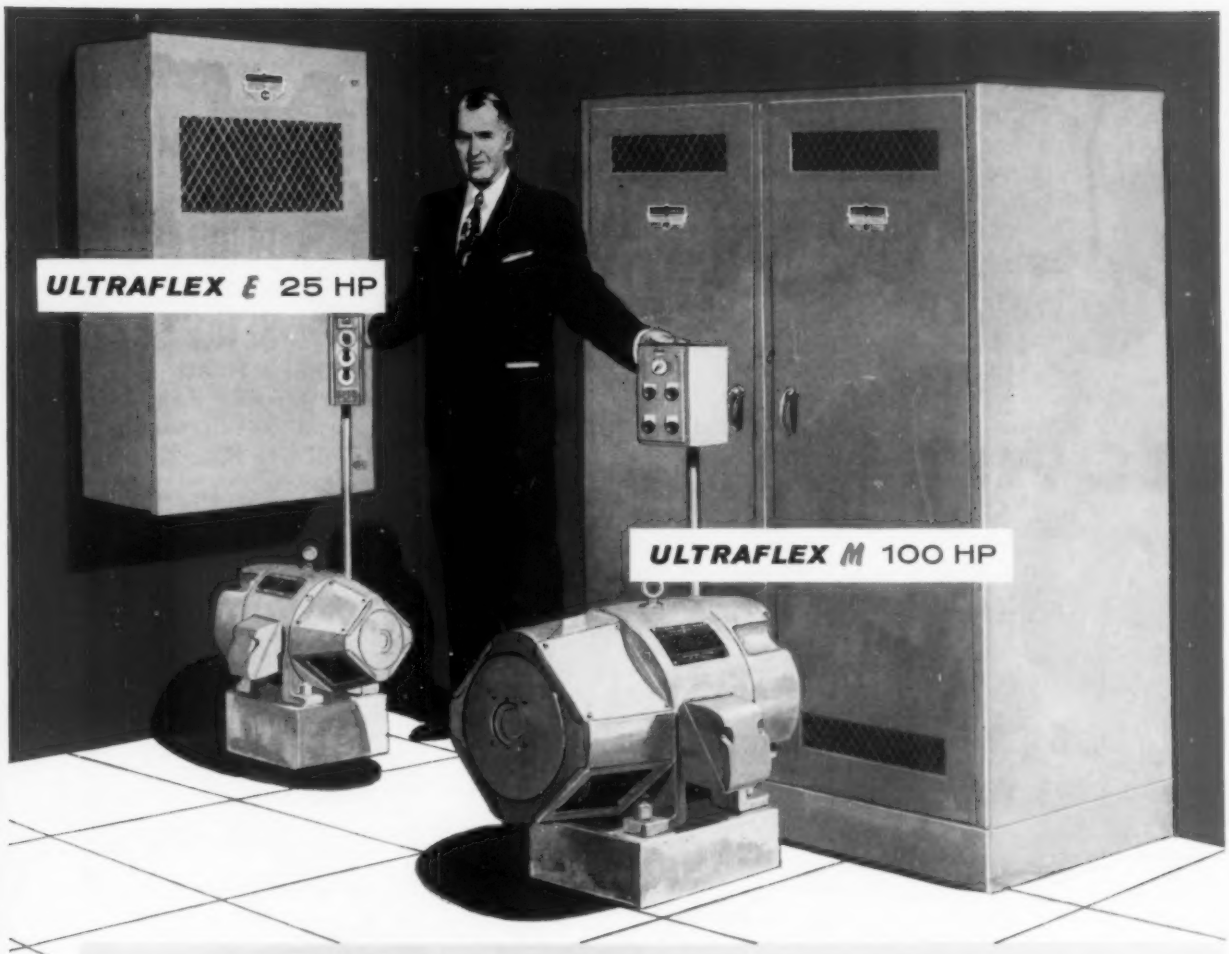
No moving parts! Simple static power conversion units require only a fraction of the time and effort needed to maintain conventional rotating type drives. With Ultraflex, there are no bearings, commutators, or brushes to service. No shafts to align. No couplings to maintain. No inertia loads to balance. No fans or filter to clean or change.

Ultraflex Packaged Drives come complete with operator's station, static power conversion unit, and heavy duty D-c drive motor. Standard Ultraflex Drives provide an 8:1 speed range with wider ranges available upon request. Optional features include dynamic braking, jogging, reversing, tach-generator speed regulation, etc.

Cutler-Hammer also provides a complete engineering service which will custom-design a static powered adjustable speed drive to meet your specific requirements. Get all the facts today, write on your company letterhead for new bulletins EN-64 and EN-65. CUTLER-HAMMER Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER·HAMMER
CONTROL
C·H

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.



ULTRAFLEX DRIVES Pack More Power per Square Foot... More Power per Pound

HP	CONVENTIONAL m-g DRIVES SQ. FT.	CONVENTIONAL m-g DRIVES LBS.	ULTRAFLEX—E SQ. FT.	ULTRAFLEX—E LBS.
5	3.89	543	Wall Mounted	215
7½	3.89	550	Wall Mounted	215
10	5.44	647	Wall Mounted	215
15	7.0	983	Wall Mounted	330
20	9.5	1830	Wall Mounted	330
25	9.5	1990	Wall Mounted	330
30	9.5	2120	6.46	625
40	13.8	2350	6.46	625

HP	CONVENTIONAL m-g DRIVES SQ. FT.	CONVENTIONAL m-g DRIVES LBS.	ULTRAFLEX—M SQ. FT.	ULTRAFLEX—M LBS.
5	3.89	543	3.5	660
7½	3.89	550	3.5	870
10	5.44	647	3.5	870
15	7.0	983	3.5	1000
20	9.5	1830	3.5	1000
25	9.5	1990	4.5	1250
30	9.5	2120	4.5	1250
40	13.8	2350	4.5	1250
50	17.8	2980	11.7	2200
60	23.3	4070	11.7	2200
75	23.3	4800	11.7	2200
100	25.2	5700	11.7	2400

ULTRAFLEX E 1 HP to 40 HP

Electronic Type Adjustable Speed Drives

Ultraflex E is the simplest, most flexible, most dependable electronic adjustable speed drive on the market today. Heavy duty power tubes have replaced all "radio type" components assuring maximum efficiency and maintenance-free operation. Standard features of design include a closed loop voltage feed back system for accurate voltage regulation, current limit control, and static rectifier field excitation. Compact design permits wall mounting of the control units up to 25 HP.

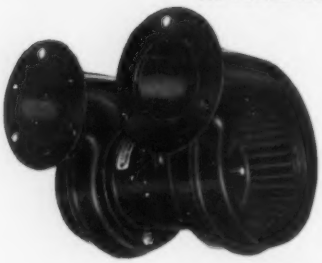
ULTRAFLEX M 1 HP to 200 HP

Magnetic Amplifier Type Adjustable Speed Drives

Ultraflex M Packaged Drives set new standards for ultra-efficient, ultra-responsive operation. Fully 15% more efficient than conventional rotating type drives, the static magnetic amplifier power conversion unit avoids all power losses due to friction, windage and the necessity of transferring power across multiple air gaps as in rotating machinery. Standard Ultraflex M drives are equipped with a closed loop voltage feed back system with IR compensation for accurate voltage regulation, current limit control, and static field excitation.

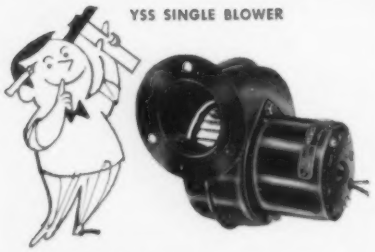
put HEINZE in your designs

YSD DOUBLE BLOWER



YS BLOWERS

YSS SINGLE BLOWER



MINIMIZE AIR NOISE

ASSURE LONG BEARING LIFE

Large (3⅝ in.) balanced air rotors, powered by a slow-speed 4 pole shaded pole induction motor, assure quiet operation and long bearing life. Blowers are enclosed in durable metal housing. YSS Single Blower delivers 50 cfm at 1650 rpm; YSD Double Blower delivers 100 cfm. Standard units operate on 115V, AC, 60 cycle. Other voltages and frequencies are available.

Applications include photographic dark rooms; laboratories; cooling of electronic tubes; kitchens; refrigeration and air conditioning units; vending machines; and similar uses.

Send coupon for technical data on the complete line of Heinze Sub-Fractional Horsepower Motors and Blowers.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

Heinze Electric Company, Dep't F
685 Lawrence St., Lowell, Mass.

Please send me technical literature and price information on Heinze Motors and Blowers.

Name & Title_____

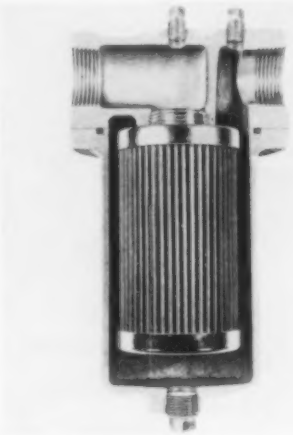
Company_____

Street & No._____

City & State_____

ing and will operate in any position. Weighs 1 oz. Alloy Bellows, 18125 Roseland Rd., Cleveland.

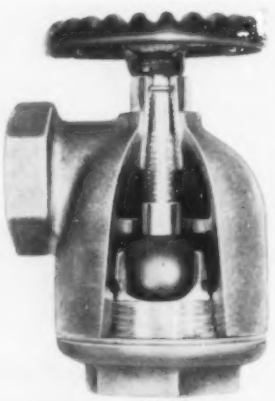
Circle 18, inside back cover



In-line hydraulic filter . . .

for suction or return lines is for service to 150 psi at temperatures to 300 F. Now being produced in sizes of 10, 20, 30, 50 and 75 gpm capacities with choice of monel wire-cloth mesh sizes from 30 to 100. All units are offered with or without bypass valve. Ample filtering area is said to permit long operation and protection for low-pressure liquid circulating systems with min downtime. Marvel Engineering Co., 7227 N. Hamlin Ave., Chicago.

Circle 19, inside back cover

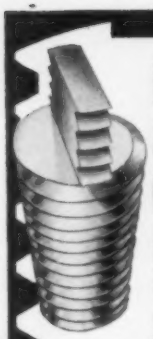


INLET

Shutoff valve . . .

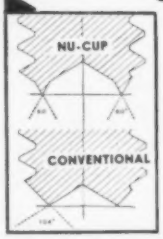
has a neoprene ball which, when stem is retracted, is forced against a beveled seat by fluid inlet pressure to form a positive seal against leakage despite heavy usage. When valve is open, ball floats free but remains axially aligned with seat. Incoming pressure helps to move ball in open-

(Continued on page 82)



LICK RECESSION COST PROBLEMS WITH SETKO

"SLABBED HEAD with NU-CUP Point" Set Screws!

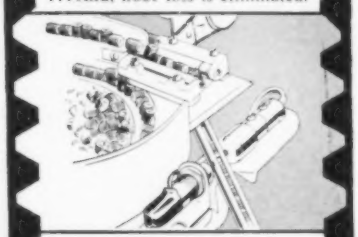


Setko Slabbed Head Set Screws are real money savers. They cost less than comparable hexagon or fluted socket set screws, yet they take greater tightening pressures . . . Up to 50% more torque without damaging.

Holding power can be even further increased when furnished with Setko's own NU-CUP, the patented holding cup point that has a 42% sharper cutting angle. Cuts are deeper and in a full circle.

CUT COSTS EVEN MORE with SETKO HOPPER FEEDING!

Now is the time to cash in on Setko's advanced method of hopper feeding . . . You get *faster* insertion rates over manual feeding — almost double . . . *Better* insertions, uniform driving pressure, better quality control. *Less expensive*, less labor is needed . . . And, floor loss is eliminated.

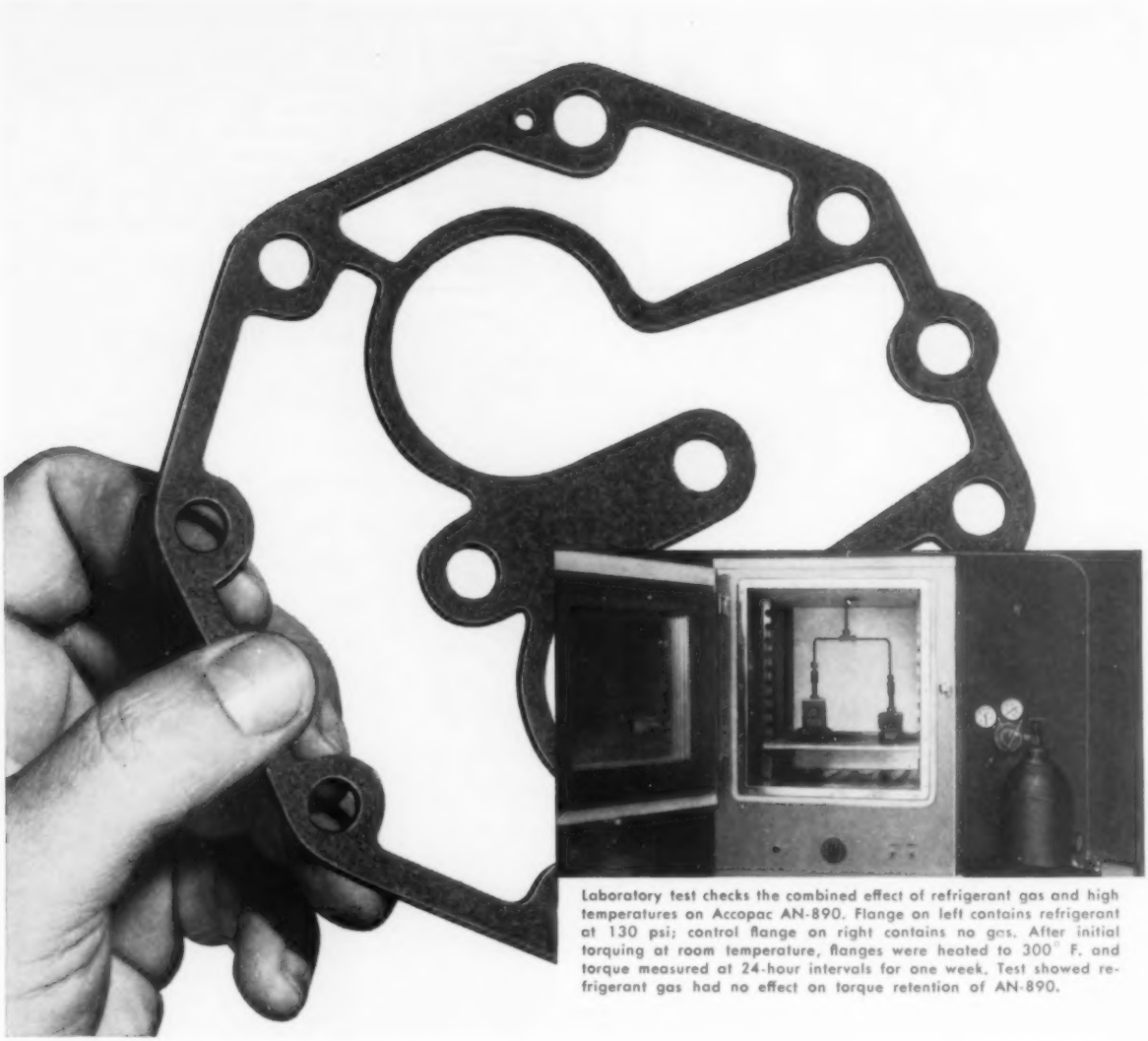


SEND FOR FREE SELECTOR CHART of Self-Locking Set Screws

Shows how and where to use over 1,001 combinations of particular applications.

Write today for full information and prices. Ask for catalog 21.

Set Screw & Mfg. Co.
U. S. Pat. No. 2,778,265
Other Patents Pending
153 Main Street, Bartlett, Illinois



Laboratory test checks the combined effect of refrigerant gas and high temperatures on Accopac AN-890. Flange on left contains refrigerant at 130 psi; control flange on right contains no gas. After initial torquing at room temperature, flanges were heated to 300° F. and torque measured at 24-hour intervals for one week. Test showed refrigerant gas had no effect on torque retention of AN-890.

Seal compressors at lower cost with new-type asbestos gasket material

More effective sealing of compressors—including those using refrigerant gases—is made possible by a new beater-saturated asbestos gasket material . . . Armstrong Accopac AN-890. This new product . . . a development of Armstrong research . . . costs considerably less than many conventional asbestos materials.

AN-890 maintains bolt torque at the ambient temperature of 300° F. common to compressor applications. And its nitrile-type rubber binder resists attack by contained fluids. Refrigerant gases which attack many gasket materials cause a slight swelling on AN-890, and this acts to improve its sealing effectiveness.

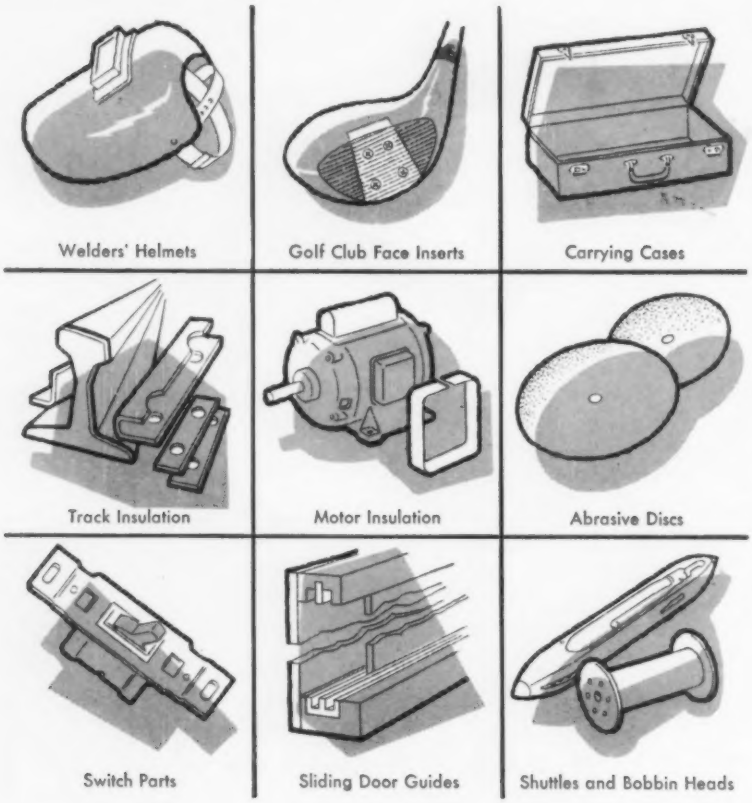
The unusual sealing characteristics of AN-890 are the result of a patented Armstrong process which combines asbestos fibers and rubber binder into a dense, homogeneous sheet that is tough and flexible. AN-890 die-cuts cleanly to the complex shapes often required by compressor designs.

Accopac AN-890 is available in rolls, sheets, ribbons, or die-cut pieces. For more information about this and other Accopac beater-saturated gasket materials, write for Bulletin IND-915. Address Armstrong Cork Co., Industrial Division, 7008 Irvin Street, Lancaster, Penna.

Armstrong ACCOPAC

. . . used wherever performance counts

A few typical applications of Taylor Vulcanized Fibre



Vulcanized Fibre Is Versatile

The applications of Taylor Vulcanized Fibre are many in number. This is because of its many unusual characteristics. It is a hard, dense material with excellent physical, mechanical and electrical properties. It is tough and resilient; has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline; it can be machined, stamped, punched and formed; it is attractive in appearance, light in weight.

Taylor Vulcanized Fibre is available in a number of different grades, in sheets, rolls and turned rods. Undoubtedly you have an application where the unique properties of vulcanized fibre can be put to work in your product. A Taylor application engineer will be glad to discuss requirements with you and recommend the best grade to fit them. Get the benefit of his advice by contacting TAYLOR FIBRE CO., Norristown 39, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

ing valve. O-ring seal eliminates stem leakage. Ball rotation causes a self-cleaning action. Valve is cast bronze with a machined brass stem. Available in angle or in-line models for pressures to 150 psi. Four-lead threads permit full-open to full-close operation with one and a half turns of stem. Sizes ¾ and 1 in. valves are available for immediate delivery. **Rene Mfg. Co., 804 Northwestern Bank Bldg., Minneapolis 2.**

Circle 20, inside back cover

Bypass flow regulator . . .

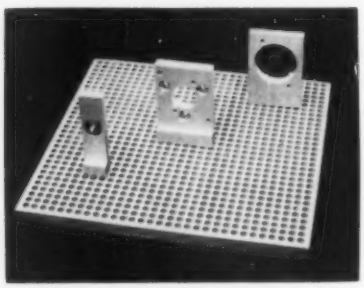
may be used at any pressure up to max (3000 psi) without affecting regulated flow or pressure. Recommended inlet flow is 25 gpm max; recommended regulated flow is 10 gpm max. **Waterman Engineering, 725 Custer Ave., Evanston, Ill.**

Circle 21, inside back cover

Split pillow blocks . . .

are offered in iron or steel housings. Equipped with spherical roller bearings, antifriction unit maintains established pillow-block dimensions while adding strength to housing. This has been done by a heavy center rib with large radii at points where housing body joins base and sturdy supports at base of housing under roller assembly. **Chas. A. Colgate Co., 528 Washington Rd., Pittsburgh 28.**

Circle 22, inside back cover



Improved bread boards . . .

and hanger units are offered from stock. Bread boards are available in 8 x 8 in., 8 x 16 in. and 16 x 16 in. sizes. Boards are jig-bored with $\frac{3}{16}$-in. holes spaced on 0.250-in. centers. High precision in actual bread board mockup is said to be obtained by use of component and bearing hangers that can be shifted to any position or facing on board. Bearing hanger's shaft-hole tolerances are held to +0.0000 to −0.0002 in. max. Component hangers are offered molded for standard size components or blank for custom boring. Hangers and bread boards are machined out of 24 ST aluminum. **Dynamic Gear Co., Inc., 20 Merrick Rd., Amityville, N. Y.**

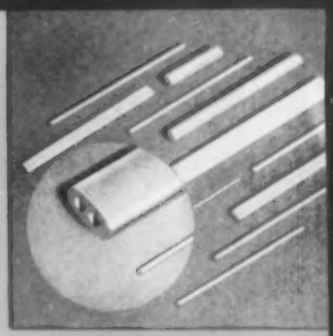
Circle 23, inside back cover

ALSiMAG®

DATA FOR DESIGNERS

Abrasion Resistant

Sand Blast Nozzles. Spray Nozzles. Hard, homogeneous, long-lived. Suited to the most exacting uses.



Precision Tolerances

Minute, yet strong tubing of AlSiMag Alumina. Parts in inset magnified three times (smaller one .013" OD); others approximate actual size.

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AlSiMag Alumina Ceramics open new fields for designers . . . permit designing to higher temperatures, higher frequencies, greater strengths.

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Do you need a material with such versatile characteristics as shown on this page? AlSimag technical ceramics have helped many designers solve problems . . . may help solve yours. Send blueprint with complete operating details for our recommendations.

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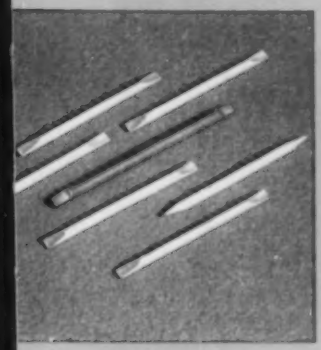
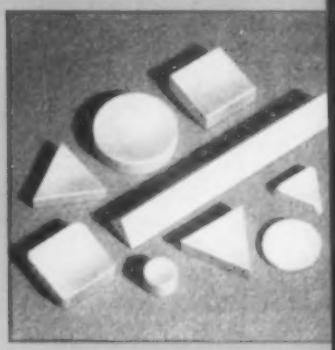


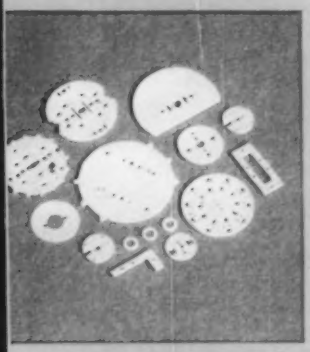
Non-Inductive

Alignment Tool Blades. Non-metallic, for sensitive machine and instrument settings—other demanding applications.



Hard

AlSiMag Tool Tips for cutting and machining strongest alloy steels.

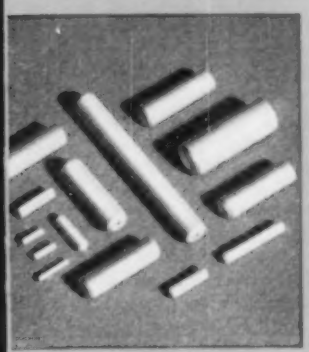


Thin . . . Strong

Electron Tube Spacers as thin as .009" have remarkable strength. Similar parts might solve other application problems where superior insulation is needed.

Durable

Rollers for flattening inductance wire—a new application for AlSiMag.



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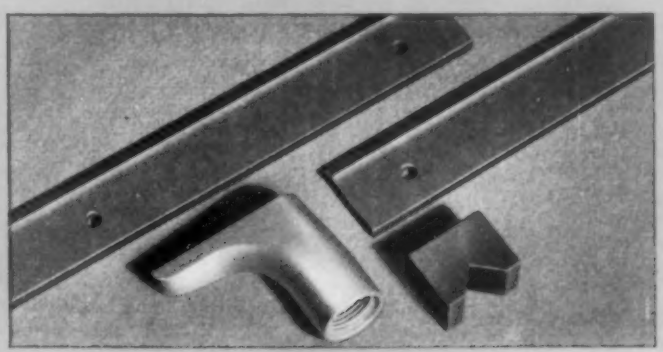
Smooth, easily coated AlSiMag Cores for Ink, Metal Film and Carbon Deposited Resistors.



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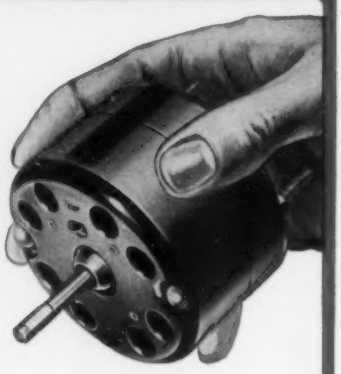

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

HIGH-PRESSURE ASSEMBLIES–Technical bulletin 200, 32 pp. Devoted to couplings suited to all types of hydraulic applications. Tables opposite dimensional cross-section drawings simplify specification of assemblies. Distributors are listed. Eastman Mfg. Co., Manitowoc, Wis.

Circle 24, inside back cover

MINIATURE SWITCHES AND COMPONENTS – Catalog G-300, 24 pp. Covers line of miniature pushbutton switches, rotary switches, binding posts, test clips and miscellaneous components. Each part is illustrated, with most shown in exploded views. Specifications covering electrical ratings, life load tests, materials, applications and construction are given. Prices are indicated. Grayhill, Inc., 561 Hillgrove Ave., La Grange, Ill.

Circle 25, inside back cover

MINIATURE ELECTRICAL CONNECTORS–Test report, 29 pp. Details laboratory tests. Describes a complete series of tests for electrical, environmental and physical characteristics. Deutsch Co., 7000 Avalon Blvd., Los Angeles 3.

Circle 26, inside back cover

MAGNETIC AND MOTORIZED VALVES–Catalog V-58, 24 pp. Illustrates and lists specifications of valves for use with air, water, gas, steam, oil and refrigerants. Also includes solenoid coil rating tables, two flow charts. With dimensional drawings. Mercoid Corp., 4201 Belmont Ave., Chicago 41.

Circle 27, inside back cover

MINIATURE GEARS – Supplementary catalog E88, 8 pp. Shows stock prices on ⅛-in. face width, Class I and II miniature gears. Dynamic Gear Co., Inc., 20 Merrick Rd., Amityville, N. Y.

Circle 28, inside back cover

AUTOMATIC VALVES – Condensed catalog P&H-58, 12 pp. Contains information on 212 valves. With specification tables including type, size, rating and shipping weights. Tables are keyed to current price sheet. Cash-Acme, P. O. Box 191, Decatur, Ill.

Circle 29, inside back cover

ELASTOMERIC MOUNTINGS–Bulletin 301, 8 pp. Describes series of mountings using broad-temperature-range elastomer and designed to protect airborne electronic equipment in temperatures from —65 to 300 F. Guide for selection and discussion of applications are also included. With performance curves, photos and dimensional drawings. Lord Mfg. Co., Erie, Penna.

Circle 30, inside back cover

DIAZOTYPE REPRODUCTION PROCESS – Booklet, 12 pp. Explains various types of direct-positive prints; how intermediates can save time, expense and work. Charles Bruning Co., Inc., 1804 W. Central Rd., Mount Prospect, Ill.

Circle 31, inside back cover

SHAFT-MOUNTED SPEED REDUCERS–Booklet B-7238, 10 pp. Discusses selection, hp ratings, dimensions, construction, installation and maintenance. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30.

Circle 32, inside back cover

LIQUID-LEVEL CONTROLS–Bulletin PF 571, 16 pp. Contains specifications, descriptive data, charts and dimensions. Selector guide is included. Photoswitch Div., Electronics Corp. of America, 1 Memorial Dr., Cambridge, Mass.

Circle 33, inside back cover

ROTARY SWITCHES–Catalog, 20 pp. Covers line of rotary multi-pole switches. Standard tap, transfer and selector switches are shown in photos and dimensional drawings, with engineering data, electrical ratings, circuit and contact diagrams and instructions for ordering. Environmental, electrical and mechanical tests performed on switches in testing lab are listed with photos of special lab equipment. Available in file size and also in miniature (4 x 5 in.) size. Electro Switch Corp., Weymouth 88, Mass.

Circle 34, inside back cover

CABLED TUBE ASSEMBLIES–Bulletin 458, 12 pp. Information on various types of tubing for instruments and controls, protective armor and types of corrosion-resistant sheaths, as well as installation instructions. Construction details are shown in cutaway views, applications in installation drawings. Crescent Insulated Wire & Cable Co., Trenton 5, N. J.

Circle 35, inside back cover

PUMPS, FLUID MOTORS AND VALVES–Catalog 100, 12 pp. Contains

(Continued on page 88)

NEW...

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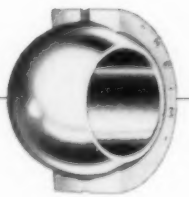
2 PIECE SPHERICAL BEARING

A brand new innovation in spherical bearing design

Through a series of controlled thermal, physical-chemical, and mechanical steps, the balls are made of high density, through-hardened powdered iron alloy, and the outer members are made of sintered iron or sintered bronze with controlled porosity.

Pressing and sintering procedures make it possible to produce a bearing which will hold up to 20% of its own volume in oil. This means longer bearing life with less frequent relubrication required. Manufacturer's tests on a 5/16" bore bearing at 1350 rpm with a 30 lb. load ran for 2000 hours with only weekly relubrication.



This cutaway view of the Unibal 2-piece spherical bearing shows how a coined (or swaged) type bearing presents a large surface-supporting area, and is capable of rotating so as to correct shaft misalignment in all directions.

Heim has been a leader in spherical bearings since their original development — an old hand with new ideas. This skill and experience can solve problems — and save money — on YOUR bearing requirements. Just call the nearest Heim bearing distributor or write direct for catalog or engineering assistance.

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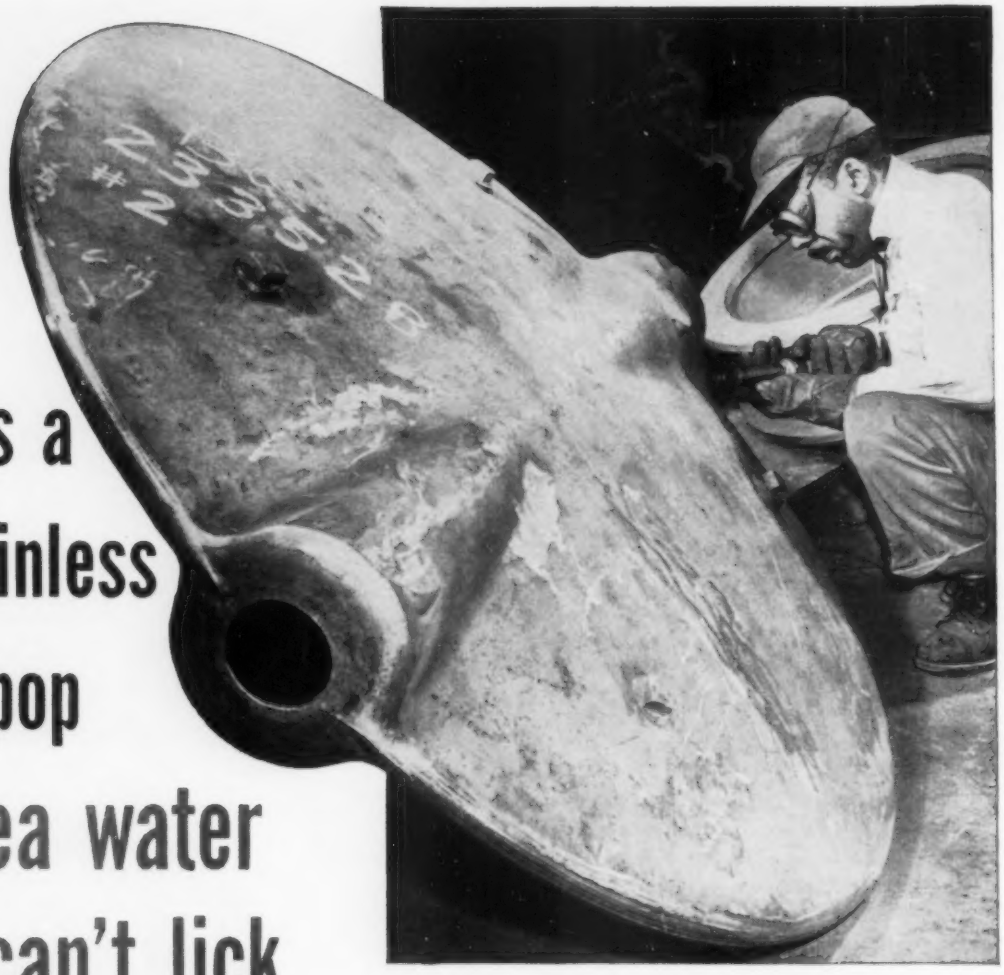
These new Unibal spherical bearings of sintered metal cost less than comparable bearings of conventional materials.

Like all Unibal spherical bearings and rod ends, the new 2-piece bearing produced by powder metallurgy, will correct misalignment to the maximum degree.

Here's a stainless lollipop sea water can't lick



This large (48″ dia., 1701 lbs.) and unusual stainless casting was fabricated by Allegheny Ludlum's Buffalo, N.Y. foundry. It is scheduled for service under the most severe operating conditions, functioning as a wafer valve disc at 25 psi pressure in sea water. Since long life and tight closing are essential in this application, corrosion resistant Type 304 Allegheny Stainless was specified.

Some unusual techniques were employed in the fabrication of this casting. Although the entire valve disc was cast as a single piece, its sides are hollow, with a skin only ¼″ thick. The center shaft was cast solid at the same time the side wings were cored, permitting the single piece, seamless part desired.

If you have a casting problem, or *any* problem that involves corrosion resistance, long life, resistance to wear and abrasion, call the Allegheny Ludlum Sales Office nearest you. An A-L Sales Engineer is ready to put his skills and those of the A-L Technical Staff promptly at your disposal, to serve your requirements from the largest and most complete line of stainless products on the market.

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28 pages of valuable and complete data on stainless castings: analyses, properties, technical data on handling and heat treatment, typical applications, how to order, etc.

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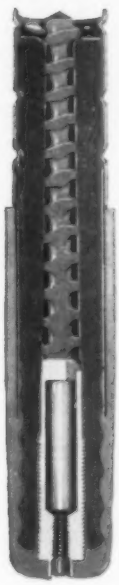
made of Spaulding Vulcanized Fibre, combining impact strength with dielectric strength.

Catcher's Shin Guard made of Spaulding Vulcanized Fibre — impact strength plus versatile forming quality.



Lightning arrestor with Spaulding Vulcanized Fibre Baffle — impact strength plus high dielectric and machining qualities.

Rolling Mill Thrust Collar of Spauldite — impact strength plus resistance to wear and pressure.

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309 Wheeler Street, Tonawanda, New York

All four of the objects shown at left must stand up to tremendous impact forces. Yet each of them combines impact strength with other unique and varying properties to do the whole job. That's why in each case the manufacturer used a Spaulding basic material.

Contact Spaulding when you have an application that calls for any or all of these properties:

- great mechanical strength
- light weight
- durability
- chemical inertia
- arc resistance
- low moisture absorption
- dielectric strength
- resistance to impact

A factory-trained Spaulding Engineer can help you select the right material and we will produce finished parts to your specifications.

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Shown with printed circuit terminals

VERSATILITY and adaptability are prime reasons why designers have made the MH a P&B best seller for such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required ... when size, weight, long life and reliability are critical ... our MH relay can usually fill the bill.

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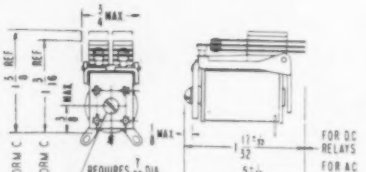
ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.
Insulation Resistance: 100 megohms minimum.
Breakdown Voltage: 500 volts RMS between all elements.
Shock: Up to 30g.
Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.
Ambient Temperature: —45°C. to +85°C. (—65°C. to +125°C. on special order).
Weight: 2½ oz. max. (open relay)
Pull-In: Approx. 75% of nominal voltage.
Pull-In Speed: Approx. 15 ms.
Drop-Out Speed: Approx. 10 ms.
Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).
CONTACTS:
Arrangements: Up to 9 springs per stack.
Material: ⅛" silver; also Palladium or gold alloy.
Load: Dry circuits to 5 amps @ 115V AC resistive.



COILS:
Resistance: 22,000 ohms max.
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)
Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.
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operating principles and internal constructions of various pumps, a pump-selection chart that classifies models according to operating requirements, construction features, mountings, packing characteristics and applicable services. Dept. PR, Tuthill Pump Co., 963 E. 95th St., Chicago 19.

Circle 36, inside back cover

ROLLER CHAIN DRIVES – Catalog D-58, 8 pp. Descriptive information, prices and tabular data on dimensions, weight, part number, number of teeth. Maurey Mfg. Corp., 2915 S. Wabash Ave., Chicago 16.

Circle 37, inside back cover

CUSTOM-MADE RODS–Folder, 4 pp. Lists data on lengths, diameters, thread lengths, head styles, and sizes and materials. Illustrations cover rods, standard fasteners and special parts. Brainard Rivet Co., Girard, Ohio.

Circle 38, inside back cover

FLEXIBLE DRIVE COUPLINGS–Brochure, 4 pp. Magnesium alloy couplings are for shaft sizes ⅜ to 6 in. Specifications, exploded view photos, and cutaway drawings are shown. Detroit Power Coupling Co., 992 W. Seven Mile Rd., Detroit 3.

Circle 39, inside back cover

PROGRAMMING DEVICES – Bulletin 100, 4 pp. Describes punched-card and tape devices, operating bases, card punch, and gives general information on applications. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J.

Circle 40, inside back cover

MECHANICAL TUBING – Technical bulletin TB-418, 6 pp. Included are tolerance tables for cold-drawn and hot-finished seamless carbon steel mechanical tubing. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Penna.

Circle 41, inside back cover

ENVIRONMENTAL TESTING – Brochure, 8 pp. Describes and illustrates facilities for testing in controlled simulations of natural climatic and mechanically induced environments. Bowser-Morner Testing Laboratories, Inc., 141 Bruen St., Dayton 1, Ohio.

Circle 42, inside back cover

PREDESIGNED MECHANISMS, COMPONENTS–Bulletin 102-58, 6 pp. Describes and illustrates components for servo and instrument fields. Gives specifications, dimensions, application data. With photos and dimensional drawings. Geared mechanisms for use in breadboarding, prototype and production applications may be assembled from available components. Precision Mechanisms Corp., 577 Newbridge Ave., East Meadow, N. Y.

Circle 43, inside back cover

ALLWAY TOOLS uses fewer parts and cuts production costs with die castings

CASE HISTORIES FROM MT. VERNON FILES

"We set out to make the best looking–best performing–best priced line of woodscrapers on the market. Die casting helped us do it", reports Mr. Gringer, President, *Allway Tools.

There's no doubt about it–Allway 4 Edge Wood Scrapers for fine and rough work, and Allway Finishing Scrapers for fine work are easily one of the best designed and easiest performing scrapers available. And a vital factor in their design and manufacture has been the full use of all the inherent advantages of zinc die casting.

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Allway takes the zinc die castings as they come in – drills and taps a hole or swages a rivet stud as required in each model – firmly stakes a steel handle to it – adds blade and vinyl grip, and the scraper is ready for market. Result – simplified, fast, low-cost production and a superior product.

When you are confronted with problems of lower production costs or product improvement, consider die casting and bring your problem to us. Our complete four-fold service will help provide the answers. Contact your nearest Mt. Vernon sales representative for quick action.

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DESIGN ABSTRACTS

Papers from ASME* Semiannual Meeting, Detroit

The Pin

Analysis indicates there are cases where shear strength is not the criterion for selection of size and type of pin. Other critical factors include mutual interaction of pin and parts to be joined—due to fit, lateral load (which can be static or dynamic). Spirally coiled pin can be used instead of any other type of same size when static and fluctuating loads are involved.

Abstracted from "The Pin," M. J. Schilhansl, Brown University, ASME paper 58-SA-23.

Storing and Availability Of Engineering Data

"A Blueprint for Storage and Retrieving of Coded Mechanical Engineering Data," E. G. Gilbo, Custom Mechanical Parts Mfg., ASME paper 58-SA-6, describes use of electronic data-processing machines and a code system for documentary and product-file information needed for research and development, design, standardization.

"Orderly and Economic Handling of Engineering Data," T. W. Schwartz, E. I. du Pont de Nemours & Co., ASME paper 58-SA-49, discusses relative merits of various documentation systems in terms of cost, simplicity, adaptability, compactness. An indexing system based on associative check lists of words related to individual subject headings and called "concept coordination" is described and evaluated.

Helical Springs

"Design of Helical Springs for Minimum Weight, Volume and Length," R. T. Hinkle and I. E. Morse, Jr., Michigan State University, ASME paper 58-SA-9, presents equations and graphs. For those cases where ID or OD of spring is fixed, aids for selection of applicable spring index are also included.

"Helical Springs of Hollow Circular Cross-section," by C. W. Bert, Battelle Memorial Institute, presents two analyses: an approximation of stresses by strength-of-materials theory and a more accurate elasticity theory solution for stresses and deflection. Measurements of strain and deflection on a tubular spring are included.

**For copies of papers, write ASME, 29 W. 39th Street, New York 18.*

Engineer-retention

Makeup of today's available engineering manpower is evaluated, incompatibility of recent graduates is discussed, reasons why engineers join unions are analyzed. NICB's six reasons for engineers' professional dissatisfaction are listed. Some actual quotes indicating what engineers want from their jobs are included.

Seven problem areas are discussed: salary structure, recruitment procedure, professionalization, job content, exit interviews, orientation and training, supervisory practices.

Abstracted from "Engineer-retention," J. D. Staley, American Management Assn., ASME paper 58-SA-45.

How to Replace Gears by Linkages

Design of 4-bar mechanism having a prescribed transmission ratio held within prescribed tolerances, for a limited range of motion, is shown. Charts for choosing mechanism with best transmission angle are included.

Abstracted from "How to Replace Gears by Mechanisms (Linkages)," Kurt Hahn and Gerhard Marx, Institut fur Landtechnische Grundlagen-forschung der Forschungsanstalt fur Landwirtschaft, ASME paper 58-SA-33.

Shaft-peening and Fatigue Strength

Relationship of shaft-peening's three effects (cold-working, residual stress, concentrations) to fatigue strength is discussed on basis of data available in the literature. Predictions of strength of manufactured parts and laboratory specimens, based on a concept attributed to Rosenthal and Sines, agree closely with observed values.

Abstracted from "Effect of Shaft-peening on Fatigue Strength," R. P. Felgar, General Electric Co., ASME paper 58-SA-46.

Loading of Spur Gear Teeth

Results of strain gage measurements of instantaneous load on spur gear teeth under static and dynamic conditions are given.

Abstracted from "Dynamic Loading of Spur Gear Teeth," by A. Y. Attia, Ein Shams University, Egypt, ASME paper 58-SA-32.

NEW ACTIONATOR*

Heavy Duty Electric Motor Operates Valves, Dampers, Louvers

This compact, rugged new industrial motor gives dependable, low-cost service. Use the *ACTIONATOR* to operate valves, dampers, louvers and other final control elements. It's available with on-off, two-position, floating or proportional control.

Features include:

- **High torque ratings**—to 200 inch-pounds.
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- **Internal brake**—to hold load in any position without coasting or hunting.
- **Great sensitivity**—the proportional control model can take full advantage of the most sensitive proportioning relays.
- **Easy adjustments**—readily accessible, field adjustable, cam-operated travel and auxiliary switches.
- **Squared end shafts**—for positive, non-slip attachment of crank arm.

For complete details on the new *ACTIONATOR* industrial motor, write for Specification S804-3, or call your nearby Honeywell field engineer.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

**Minneapolis-Honeywell tradename*

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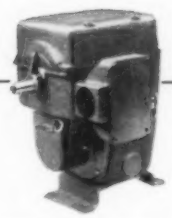
First in Controls



NEW INDUSTRIAL VALVE MOTOR

Series 831E has extra power for highly accurate control

This powerful new Industrial Valve Motor is designed primarily for valve and damper applications. It is suitable for many other control applications where high accuracy and reproducibility are required. Some of its outstanding features:

- Positive control action without coasting.
- Accurate positioning of final control elements over full drive shaft rotation.
- Arc-suppression circuit to protect auxiliary relays.
- Variety of speeds (3 to 120 seconds) and modes of control available.
- Rated output torque—up to 62.5 ft. lbs.

For details, write for Specification S804-2, or call your nearby Honeywell field engineer.

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NEW BOOKS

Fluid Mechanics

VICTOR L. STREETER, *Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36.* 6x9, 480 pp. $7.50.

This book has been updated to include recent information on subjects such as fluid properties, dimensional analysis, and negative surge waves. It is primarily a textbook, college level, and provides very clear introductions to the fields of statics, dynamics, compressible flow and ideal 2-dimensional flow. Its mathematics are complete, from very simple static concepts up to 2-dimensional flow and simple shock waves but leaves higher mathematics (such as found in 3-dimensional flow) to Mr. Streeter's more advanced *Fluid Dynamics* (also published by McGraw-Hill). All of the fundamentals are given for Newton's Law, Bernoulli's Theorem, Venturi Flow . . . also adiabatic, isentropic and potential flow. Many problems are given to the student to work out and they include usual assortment of weirs, dams, orifices and pipes.

Last portion of the book includes practical applications of hydraulics with illustrations of turbo machinery, all measuring devices, conduits, control systems, and hydraulic components.

Control Engineering Handbook

JOHN G. TRUXAL, *Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36.* 6x9, 1048 pp. $18.50.

This book is a fairly successful effort to give identity to the ever growing profession of control engineering. It combines electronics, magnetics, solid-state physics, packaging, electrical and mechanical engineering, hydraulics, pneumatics, communications and over-all systems.

Components and techniques are stressed. Physical explanations, mathematical descriptions, operating characteristics, measuring techniques and limitations are given for every type of control problem. Extensive details are included. Perhaps a fault is the lack of simpler fundamental descrip-

(Continued on page 94)

When your product must respond to temperature or pressure changes . . .

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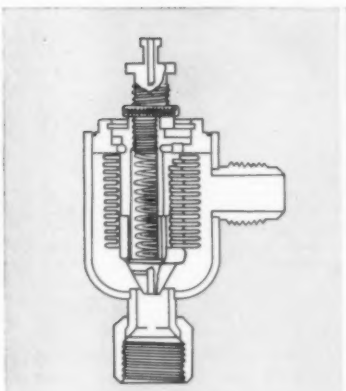

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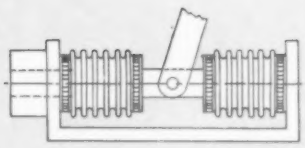

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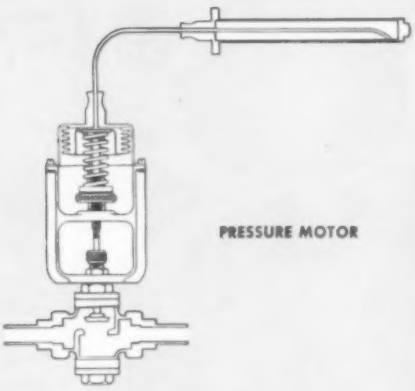

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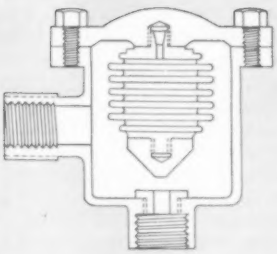

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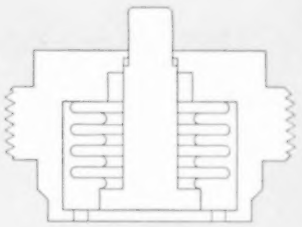

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tions necessary for an engineer who may be studying out of his field. In other words, this is a handbook (with a high percentage of textbook-type information) written by experts for experts.

It has the combined equivalent of a half dozen high-powered textbooks and thoroughly covers such control topics as the theory of LaPlace transforms and feedback control systems. Included are extensive charts and equations of transfer functions, stability criteria, nonlinear systems, control circuit problem-solving techniques, and theory of computers.

Typical control-design problems show uses of magamps, transistors, thyratrons, contactors, relays, power supplies, mechanical components, clutches, brakes, hydraulic and pneumatic components, transducers and regulators. The last chapter shows typical process equations and their solutions. The 75 pages of index make everything easy to find.

Rocket Building for Students

Compiled by GEORGE S. JAMES. *Published by Rocket Research Institute, Inc., 3262 Castera Ave., Glendale 8, Calif.* 8½x11, 80 *pp.* $2.

Purpose of this manual is to encourage safety among amateur rocketeers and direct their interests along rewarding paths. It describes in detail the construction and testing procedure for several typical small rockets which can be made by a high school student with common drugstore-variety chemicals and model airplane-building techniques. Safety in both construction and testing is emphasized throughout.

Recent Advances in Engineering Sciences

Published by McGraw-Hill Book Co. 330 W. 42nd St., New York 36. 6¼x9¼, 256 *pp.* $4.75.

On Sept. 9-12, 1957, deans of engineering attended a conference at Purdue University in which recognized authorities in various scientific fields reviewed recent technological progress. This book collects the papers presented at that conference.

Topics covered are: automation and automatic control; operations research and systems engineering; administra-

(Continued on page 97)

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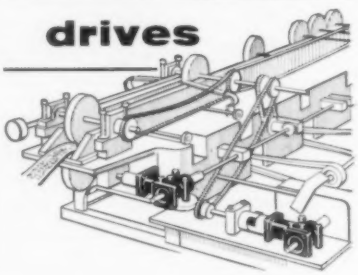

Prototype of this belt-finishing machine utilized exposed miter gears for 90° drive (foreground). Change to ANGLgears solved problems of noise, lubrication failure, disengagement and operator safety.

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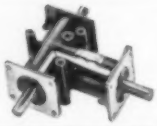

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MOLY NEWS

CLIMAX MOLYBDENUM CO. DIVISION • AMERICAN METAL CLIMAX, INC.

Climax Develops an Extremely Tough, Abrasion-resistant Chrome-Moly White Iron

New Alloy Proves Superior in Erosive Applications

A new martensitic white iron has proved exceptionally tough and resistant to abrasion. It's called Alloy 42. Its excellent combination of properties are related to its structure — which consists of hard chrome-moly carbides favorably distributed in a matrix of martensite plus retained austenite.

Tests indicate Alloy 42 is especially economical for parts subject to erosive wear: sand pumps, flotation impellers, sand classifier wear shoes, pug mill blades, brick mold liners and chute liners.

For example, heat-treated Alloy 42 impellers in a 5" sand pump handling coarsely ground taconite ore have already lasted over 1,000 hours. Previous impellers made of a 4.5% Ni, 1.5% Cr type of martensitic iron lasted only 350 to 400 hours.

Because of its toughness, Alloy 42 can also be used where moderate impacts would cause low alloy types of white iron to break or spall. And it may prove more economical than the soft rubber parts or linings now used in various abrasive applications. Its resistance to tearing by tramp coarse materials and chemical attacks by oils and other organic compounds is an obvious advantage.

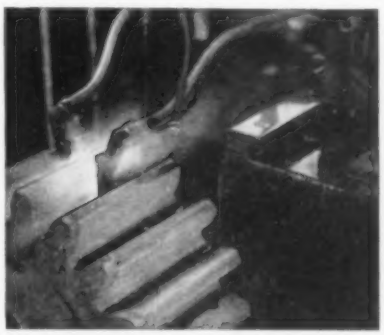
The recommended composition range is: Carbon 3.00-3.50%; Silicon 0.30-0.60; Manganese 0.60-0.90; Chromium 15.0-18.0; Molybdenum 2.75-3.25.

A Climax bulletin on Alloy 42 discusses melting and casting, molds and shrinkage, heat treatment, structure, physical properties, machinability, welding and cutting. *For a free copy, circle #1 on the coupon.*

Heat Treating Improves the Wear Resistance of Gray Iron

Heat treating can improve many of the properties of gray iron, particularly resistance to wear. Wear resistance in quenched-and-tempered gray iron is many times greater than that of pearlitic irons. With cams and similar parts, hot quenching provides better wear resistance than quenching and hardening to the same hardness. Surface hardening is frequently selected for gray iron because it locally improves wear resistance with minimum distortion.

Why Moly Iron Bulletin #6 contains valuable information on surface hardening, annealing and stress-relieving molybdenum-alloyed irons. This bulletin gives examples of improvements obtained by heat treating gears, cable drums, pump-ring castings, tappets, valve guides and machine tool ways.



Flame hardening the teeth on a sprocket improves wear resistance with minimum distortion.

For a free copy of ***"Why Moly Iron Bulletin #6,"*** *circle #2 on the coupon.*

Tempering Low-Alloy Creep-Resistant Steels

A recent British paper discusses the roles of chromium, molybdenum and vanadium in low-alloy steels with high creep strength. The relation between creep properties, microstructure changes and carbide composition is given special attention.

For a copy of ***"The Tempering of Low-alloy Creep-resistant Steels Containing Chromium, Molybdenum and Vanadium"*** *by E. Smith and J. Nutting, circle #6.*

Moly Helps High Alloys Fight Corrosive Attacks

Highly alloyed materials are playing a greater part in combating corrosion. A current paper on these alloys considers the molybdenum-bearing alloys at length and also discusses cobalt-base alloys and silicon-bearing alloys.

For copies of this paper, ***"High Alloys to Combat Corrosion"*** *by E. D. Weisert, circle #7.*

Thermenol Shows Excellent Resistance to Heat, Corrosion

Thermenol, an iron-aluminum-molybdenum magnetic alloy, compares favorably with other high-temperature materials, and in some cases promises even better service. For unlike many alloys, it doesn't lose tensile strength rapidly up to 1200 F. It also has excellent resistance to oxidizing and sulfur-bearing atmospheres at high temperatures.

For a copy of ***"Iron-aluminum Magnetic Alloy Has Excellent Heat Resistance,"*** *circle #8.*

Moly in Nickel-base Casting Alloys Improves High Temperature Service

Molybdenum is helping at least two nickel-base alloys to work more effectively in high temperature applications. One of the alloys, with 5% Mo, combines good castability with very good creep strength at temperatures up to 1800 F (much better than that of moly-free alloys). The second, with 10% Mo, shows high resistance to thermal shock.

For free copies of ***"Some Properties of Nickel-base Casting Alloys for High-temperature Service"*** *by D. R. Wood and J. F. Gregg, circle #3.*

Cast Steels Studied at Low Temperatures

The British Steel Castings Research Association has completed new studies on the effect of melting practice, composition and treatment of steel castings. Five of the seven alloy steels investigated contained molybdenum. The benefits of using molybdenum in low alloy steel castings for low temperature service are clearly shown in comparisons of 1.5% Mn and 1.5% Mn-Mo.

For reprints of ***"The Low-temperature Impact Properties of Cast Steel"*** *by W. J. Jackson and G. M. Michie, circle #4.*

New Data Available on Low Carbon Bainitic Steels

Studies have been made on new steels based on boron-0.5% Mo. Tensile strengths up to 180,000 psi can now be obtained within the bainitic range with a wide range of cooling rates. Thus these low-carbon bainitic steels offer a good combination of mechanical properties as-rolled or as-air-cooled. These properties can be obtained in large sections because hardenability is high. Good welding properties and tempering characteristics make the steels especially suitable as high-strength weldable steels, forgings, die blocks, etc.

For copies of ***"Low-carbon Bainitic Steels"*** *by K. J. Irvine and F. B. Pickering, circle #5.*

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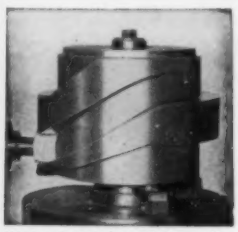
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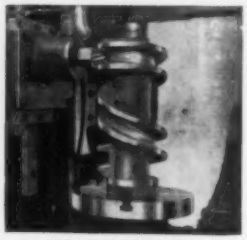
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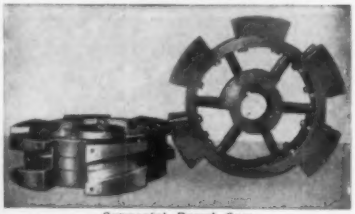
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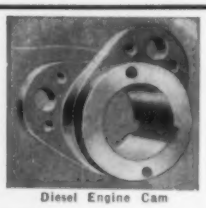
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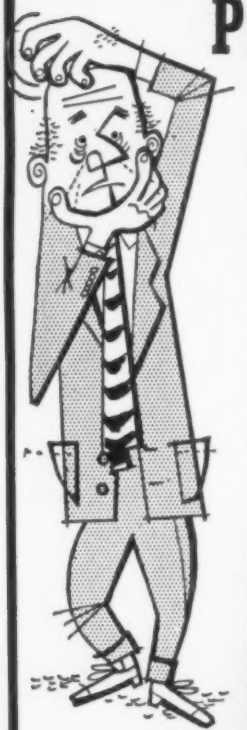

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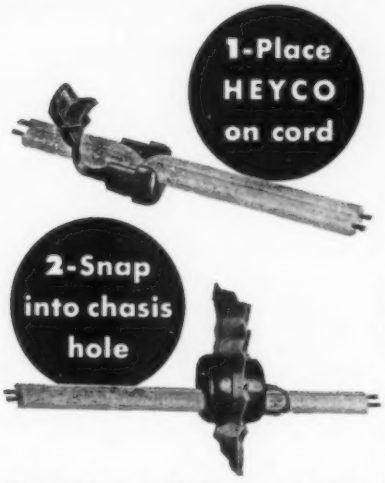

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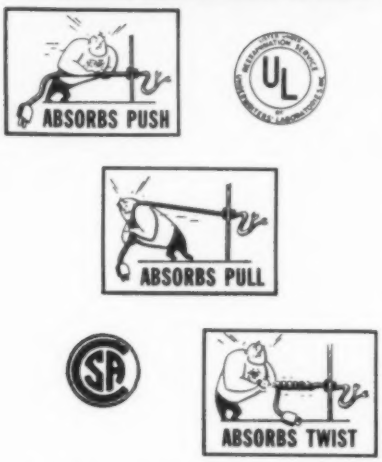

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Kodak Publication No. M-1. Published by Eastman Kodak Co. Rochester 4, N. Y., 5¾x8½, 50 pp, 50 cents.

When photographs, drawings, sketches or printed matter must be copied, this booklet, now in its sixth edition, will be helpful. It describes in detail latest techniques and equipment for all types of photocopying, microfilming, and contact copying. It includes lighting, exposure and processing recommendations when copying either black-and-white or color.

ASTM Standards on Iron Castings

Published by American Society for Testing Materials, 1916 Race St., *Philadelphia* 3. 6x9, 158 pp. $2.75.

Those who specify or test cast iron will find this new standard helpful. It gives established standards, tentative specifications, and methods of test for all types of cast iron—pig, gray, nodular and malleable. These represent the most up-to-date thoughts and practices. They are recommended for industry usage because of substantial agreement among groups represented on committees of the Society.

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This damping type motor tachometer is less than 2-inches long, but offers a new high in performance for a size 10 frame. Minimum stall torque is .5 in.-oz.; the high output gradient is .500 volts per thousand rpm and operating temperatures range from −54°C to +105°C. Standard models wound for 30 volts, 400 cycles. Variations to order.

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While the supply lasts, single copies of the following reprints are obtainable by using the Reader Service Card.

Swivel Joints

Guide for choosing between swivels and other flexible connections such as rubber or metal base. Aug. 4, '58, p. 40.
Circle No. E 37

Torque-limiting Devices

Analysis of 17 new and conventional ways to prevent motor overloading and strain on equipment. Aug. 4, '58, p. 50.
Circle No. E 36

Time-displacement Records

Mechanical drum recorder offers the simplest way to get T-D records. Comparison between drum camera and its three rivals. July 21, '58, p. 78.
Circle No. E 34

Heavy Metal

How high-density alloys may be used to solve design problems involving space and balancing. July 21, '58, p. 62.
Circle No. E 33

Stresses in Adhesive Joints

How to calculate stress concentrations of 6 basic joints. July 7, '58, p. 64.
Circle No. E 32

Designing with Cantilever Springs

Equations for 7 types show how to triple energy capacity. July 7, '58, p. 58.
Circle No. E 31

Design for Automatic Production

Product, and machine to make it are designed together for small or large quantities. June 23, '58, p. 81. Circle No. E 30

Electrical Control Enclosures

Guide for mounting and protecting con-

(Continued on page 101)

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by **B. FRANK HANTZ,** *Vice President*
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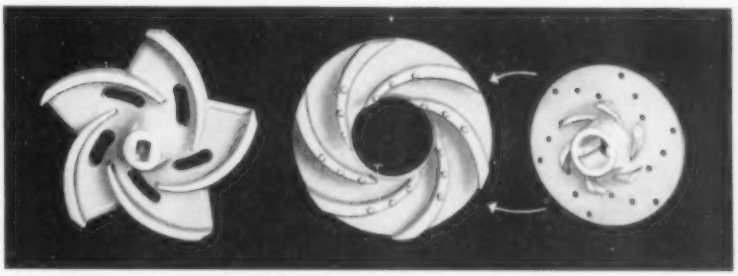

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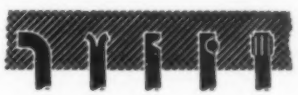

INSERTS . . . may be used in plastic parts as fasteners, to support loads, simplify handling or facilitate assembly. (They may serve functional purposes or may be used purely for decoration.) Smooth rod inserts (see sample above) may be securely anchored by bending, splitting, notching, swaging or knurling. Other types of inserts are fully covered in Aico's booklet "Good Plastics Design Makes Cents." Coupon will bring your FREE copy.

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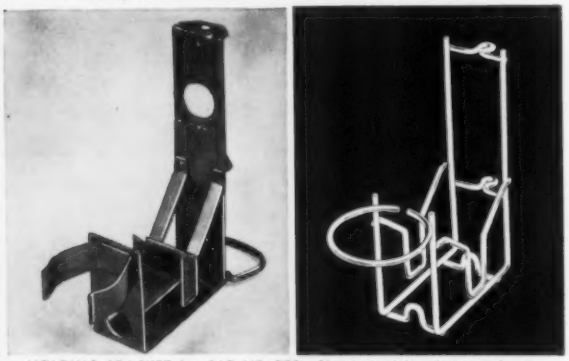

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A 16-page printed index of editorial content in all issues for the first six months of 1958 is now ready. Copies may be obtained by circling No. E 35 on one of the Reader Service Cards bound inside the back cover of this issue.

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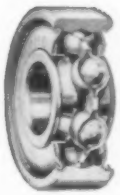

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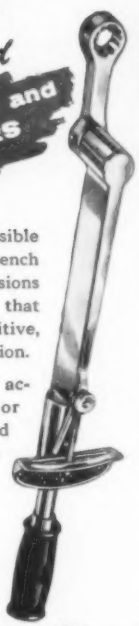

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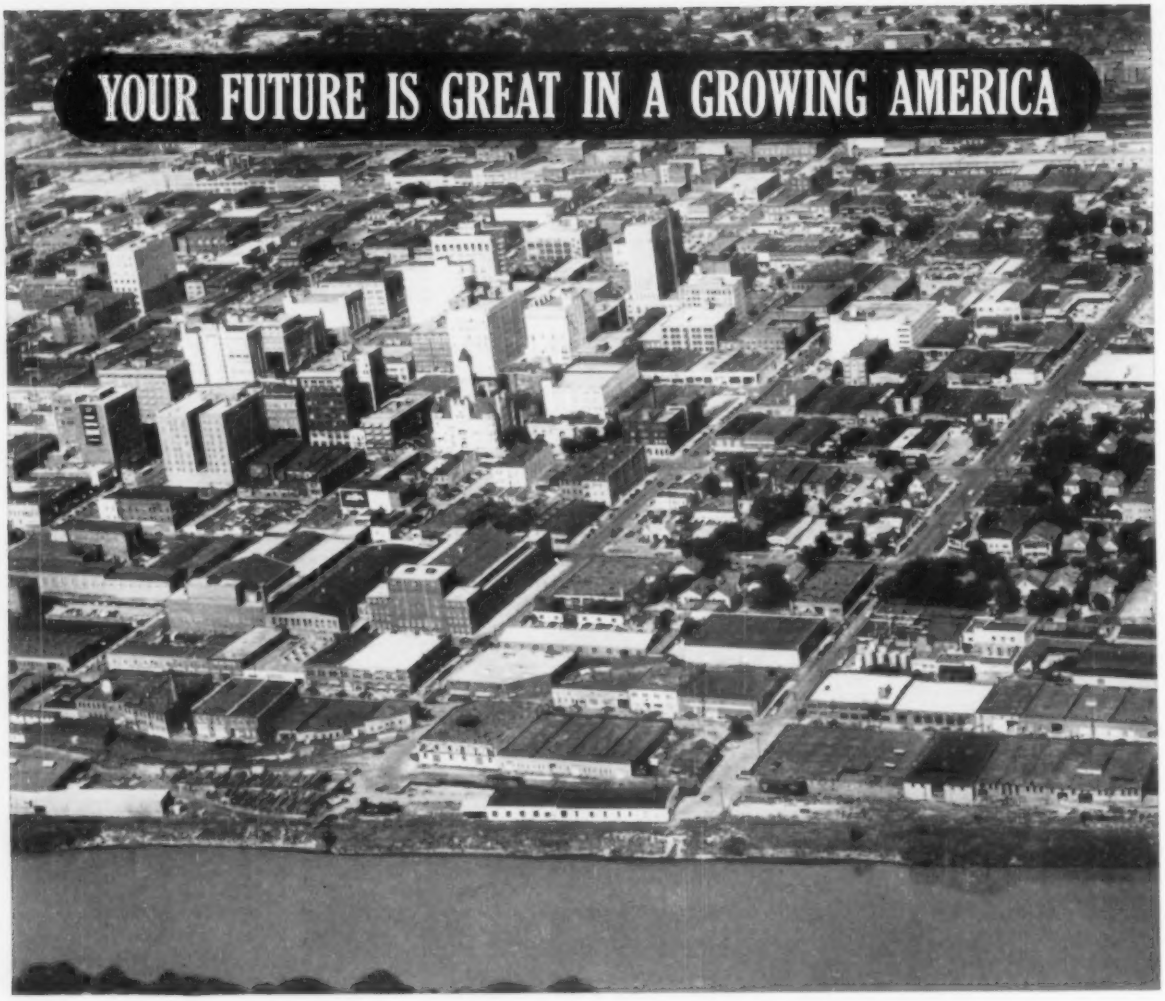

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4. **More production** . . . U. S. production *doubles* every 20 years. We will require millions more people to make, sell and distribute our products.
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(This space contributed as a public service by this magazine.)

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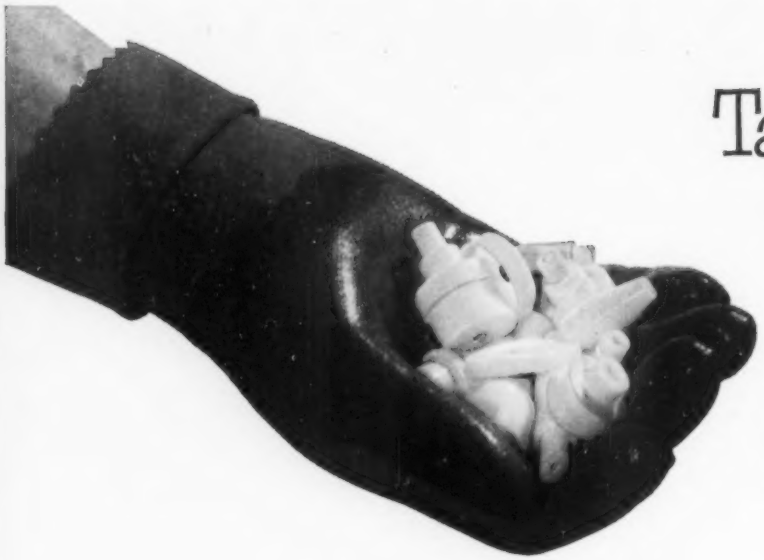

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METALS AND ALLOYS

15—Viny-to-metal Laminate

POWER TRANSMISSION

1—Torque Converter

11—Miniature Magnetic Clutches

14—Flange-mounted Drive

E25	E26	E27	E28	E29	E30	E31	E32	E33	E34	E35	E36	E37
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270	271	272	273	274	275	276	277	278	279	280	281					

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*Multiple product ads.

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GENERAL ENGINEERING

31—Diazotype Reproduction Process, 12 pp., Charles Bruning Co.

42—Environmental Testing, 8 pp., Bowser-Morner Testing Laboratories.

POWER TRANSMISSION

32—Shaft-mounted Speed Reducers, 10 pp., Westinghouse Electric Corp.

MECHANICAL PARTS

28—Miniature Gears, 8 pp., Dynamic Gear Co., Inc.

30—Elastomeric Mountings, 8 pp., Lord Mfg. Co.

35—Cabled Tube Assemblies, 12 pp., Crescent Insulated Wire & Cable Co.

37—Roller Chain Drives, 8 pp., Maurey Mfg. Corp.

38—Custom-made Rods, 4 pp., Brainard Rivet Co.

41—Mechanical Tubing, 6 pp., Babcock & Wilcox Co.

43—Predesigned Mechanisms, Components, 6 pp., Precision Mechanisms Corp.

wealth of vital information . . .

Components and Materials Appearing on Pages 67-82

MECHANICAL PARTS

13—Self-lubricating Bearings
22—Split Pillow Blocks

ELECTRICAL, ELECTRONIC COMPONENTS

2—Mercury Pushbutton Switch
3—Relay Has No Moving Parts
16—Flat Snap-action Switch
17—Electronic Relay
18—Miniature Pressure Switch

HYDRAULIC, PNEUMATIC EQUIPMENT

4—Miniature Air Cylinders
7—Small Bore Cylinders
8—Self-locking Adjustment
19—In-line Hydraulic Filter
20—Shutoff Valve
21—By-pass Flow Regulator

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5—Modular Electronic Counters
6—Hydraulic Power Check
9—Miniature Hysteresis Motor
12—Cam-operated Indexing Unit
16—Machine Tool Motors

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Bulletins (p. 84-88)

FASTENING AND JOINING

35—Flexible Drive Couplings, 4 pp., Detroit Power Coupling Co.

MOTORS, ENGINES AND CONTROLS

33—Liquid-level Controls, 16 pp., Electronics Corp. of America
36—Pumps, Fluid Motors and Valves, 12 pp., Tuthill Pump Co.
40—Programming Devices, 4 pp., Industrial Timer Corp.

ELECTRICAL, ELECTRONIC COMPONENTS

25—Miniature Switches and Components, 24 pp., Grayhill, Inc.
26—Miniature Electrical Connectors, 29 pp., Deutsch Co.
34—Rotary Switches, 20 pp., Electro Switch Corp.

HYDRAULIC, PNEUMATIC EQUIPMENT

24—High-pressure Assemblies, 32 pp., Eastman Mfg. Co.
27—Magnetic and Motorized Valves, 24 pp., Mercoid Corp.
29—Automatic Valves, 12 pp., Cash-Acme

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October 18, 1957

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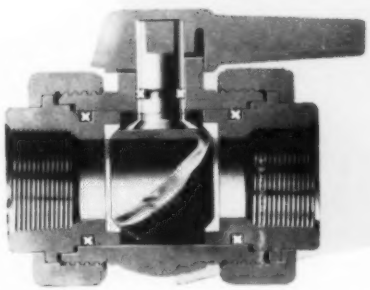
We wish to further express our appreciation of the fine service extended us by your engineers, both in promptness of supply, engineering assistance and in addition, the cooperation of your laboratory in supplying us with data and special components that enable us to better serve our customers.

Yours very truly,
CHEMTROL CORPORATION

Martin Usab, President



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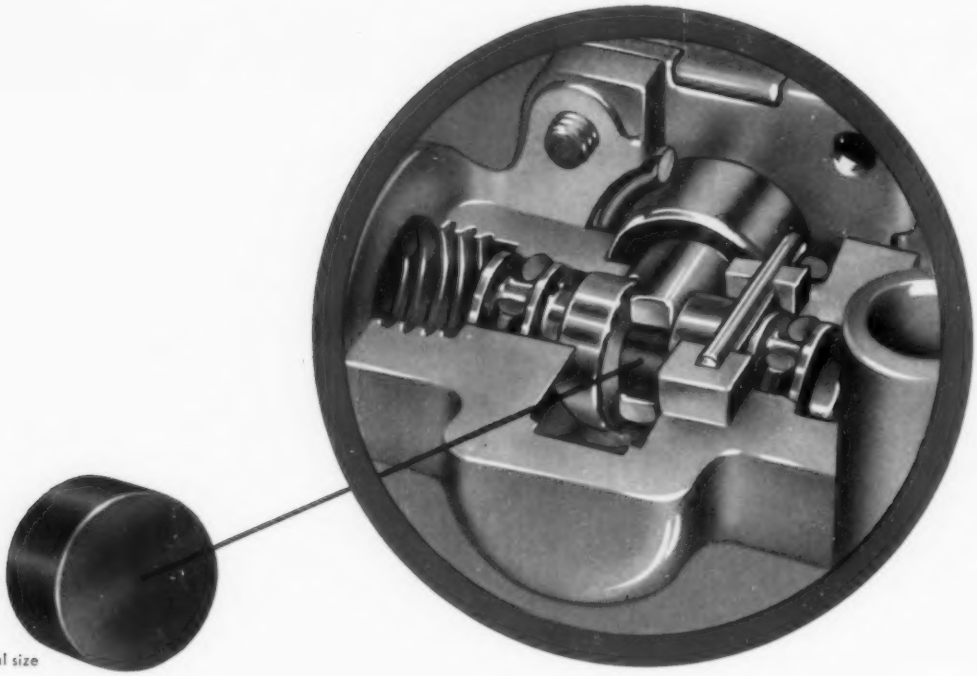

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VALCOR solenoid valve relies on a self-lapping GRAPHITAR® disc.

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These solenoid valves manufactured by Valcor Engineering Corp. of Kenilworth, New Jersey, incorporate a "floating seal" of GRAPHITAR, and are helping to launch the new age of guided missiles in America. Over half a million Valcor valves are in use in military aircraft and guided missiles today.

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